TAMPERE UNIVERSITY OF TECHNOLOGY

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IMPROVING TRANSPARENCY IN DEMAND-SUPPLY CHAIN WITH VISUAL BUSINESS INTELLIGENCE TOOLS

Master of Science Thesis

Prof. Hannu Kärkkäinen has been appointed as the examiner at the Council Meeting of the Faculty of Business and Technology Management on November 5th, 2014.

ABSTRACT

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Humans acquire more information through their visual systems than through all other systems combined. That is why we understand things better and faster when we see them. Visuality has been exploited in business environment already for a long time but the increasing amount of data and the recent development of data processing technology have brought up new opportunities and challenges for visualization. This research examines visual business intelligence and its opportunities firstly by examining scientific literature related to the subject. Later on this knowledge is made use of in improving transparency in the target organization. Visual business intelligence is quite unfamiliar term in scientific literature and most of the reference material use data visualization or visual analytics as the term.

Visualization was seen as a versatile benefit for transparency improvements in target organization. Hence two slightly different visualization tools were developed. Business-discovery platform Qlikview was decided to be the base for these tools because it was already in wide use in the target organization. During the development process some improvement issues were discovered relating company data and processes. Research results still show that solutions developed during development phase have increased transparency in minor level in the demand-supply chain. Transparency was improved by improving communication and helping employees to see their business better. By taking suggested actions the transparency in the organization shall increase more.

TIIVISTELMÄ

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Tietojohtamisen koulutusohjelma

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Ihminen omaksuu enemmän tietoa näkökykynsä kautta kuin kaikilla muilla aisteilla yhteensä. Siksi ymmärrämme asioita paremmin ja nopeammin kun näemme ne. Visualisuutta on hyödynnetty jo pitkään yritysmaailmassa mutta kasvava datan määrä ja kehittynyt prosessointiteknologia ovat viime vuosikymmenen aikana tuoneet uusia mahdollisuuksia ja haasteita visualisoinnille. Tässä tutkimustyössä perehdytään visuaalisen liiketoimintatiedonhallinnan mahdollisuuksiin ensiksi tutustumalla alan tieteelliseen kirjallisuuteen, ja sen jälkeen hyödyntämällä tätä tietoa kohdeorganisaation tilaus-toimitusketjun läpinäkyvyyden lisäämiseksi. Visuaalinen liiketoimintatiedon hallinta osoittautui melko tuntemattomaksi termiksi tieteellisessä kirjallisuudessa ja suurin osa lähdeaineistosta käyttää termejä datan visualisointi tai visuaalinen analytiikka.

Kohdeorganisaatiossa koettiin visualisoinnista olevan monipuolisesti hyötyä läpinäkyvyyden lisäämiseksi, jonka myötä kahta hieman erilaista visualisointityökalua lähdettiin kehittämään. Työkalujen pohjaksi valikoitui business-discovery alusta Qlikview, joka oli jo valmiiksi laajassa käytössä kohdeorganisaatiossa. Työkalujen kehitystyön myötä huomattiin kehitystarpeita kohdeorganisaation datassa ja prosesseissa. Tutkimustulokset kuitenkin näyttävät, että jo tutkimusprojektin aikana luodulla uudella visualisoinnilla lisättiin tilaus-toimitusketjun läpinäkyvyyttä parantamalla työntekijöiden kykyjä havainnollistaa kokonaisuutta itselleen ja muille, sekä helpottamalla kommunikointia heidän välillä. Jatkokehitysehdotuksia noudattamalla kohdeorganisaation läpinäkyvyys tulee kasvamaan entisestään.

PREFACE

When one door closes – another one opens. Studying at TUT for the past seven years has been one huge roller-coaster and now wistfully I am writing these last phrases of my thesis and my degree. In one hand I feel unready to leave behind the comfy status of a student; which has allowed many lazy spring days spent on the sunny front lawn and countless numbers of inappropriately timed bottles of sparkling wine have been passed on. On the other hand I know that the world is full of possibilities for new roller-coasters and discoveries and with the Master of Science diploma in my hand I am eager to shred the student status off my shoulders and go and explore these new possibilities.

I want to thank my thesis examiner Hannu Kärkkäinen for guiding me through the thesis project and my instructors from Valmet: Markku Kivistö and Teemu Kakko for taking me in to the company for this master's thesis project. Kudos to my parents as well who have been irreplaceable listeners throughout this thesis project and my life.

Like it has always been, spring is the best time for change. Thanks Tampere University of Technology!

Heidi Korhonen

25.3.2015

TABLE OF CONTENTS

ABBREVIATIONS AND NOTATIONS

Business Intelligence (BI)	Set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information (Evelson, 2008)
Customer Relationship Management (CRM)	Managing the interaction with current and future customers.
Data	Symbols (Bellinger et al. 2004)
Data Visualization	Representation of raw data in a visual form or the process of creating it
Demand-supply chain (DS-chain)	Customer driven value chain that includes organizations functions from sales and marketing to delivery and warranty
Information	Processed data in useful form (Bellinger et al. 2004)
Knowledge	Applicated data and information. Answers the “why” question (Bellinger et al. 2004)
Qlikview	Business discovery platform for retrieving data from different sources (Qliktech, 2011)
Visual Business Intelligence	Set of visual methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information. Umbrella term for data visualization.

1. INTRODUCTION

Today the average man encounters more data in a day than his counterpart in his entire life during the 15th century. It is also known that humans acquire more information through their visual system than through all other senses combined. That is why we understand things better and quicker when we see them. (Simon, 2014). Visuality eases cognitive processes which makes it possible to acquire large amounts of visual information fast. Visualization is the process of representing data as a visual image (Latham, 1995). With visualization, one can communicate complex information, help understand complicated relationships between multiple variables, uncover information hidden in the data and solve problems through visual representation in the form of data structures for expressing and sharing knowledge (Sackett et al. 2006).

Visual business intelligence creates insight by combining this humans' most powerful way to acquire information with modern information systems that transform raw data into meaningful and useful information. The goal of visual business intelligence is to improve insight, reasoning and understanding (Patterson et al. 2014). This master thesis examines how visual business intelligence can improve transparency in target organization's demand-supply chain and can it lead to faster and more fact-based decision-making.

This master's thesis firstly presents how decision-making works and then examines what transparency is and why is it wanted in the target organization. The hypothesis is that better transparency generates faster and more fact-based decisions. Visual business intelligence (later on also referred to as data visualization) is thoroughly presented to create a framework for the reader. Afterwards this framework and presented visual business intelligence tools are used to design transparency improvements in the target organization. Observations are limited to demand-supply chain and more precisely to sales and delivery processes. But the results are constructed so that they are applicable to other processes as well. Emphasis is on the needs and requirements of the target organization and the visual business intelligence tools in use.

1.1. Purpose of this study

The purpose of this study is to improve efficiency in the target organization by increasing transparency in their demand-supply chain. Other purpose of this study is to form better image of possibilities of data visualization and the future benefits of it. Through this study the target organization can benefit more from their data and this way work more effectively and productively.

During the master's thesis process, many possible development subjects arose. The next section will refine the chosen research problem through the main and sub research questions that have been guiding this study.

1.2. Research problem and research questions

The target organization is a large player worldwide in the paper, pulp and energy industries. Their history dates back to the late 19th century and the current organization is formed from multiple different companies through mergers and demergers over the last decades. The organization is facing problems that many this type of large and old organization faces. Because of their widely spread operations and data, it is difficult to obtain the right information in a right time.

The organization is determined to take action to address this problem. Based on this decision following study is performed and the following research questions formed to guide the research process.

Research questions

Main research question

How data visualization can increase transparency and therefore enhance fast and fact-based decision-making in demand-supply chain?

Sub-questions

- Why transparency is wanted in the case company?
- What are the characteristics of data visualization that influence decision-making process?
- What are the current problems related to transparency or the current information needs in the case company that could be solved with data visualization?
- How the created solutions can help to increase the transparency in DS-chain and especially in sales and delivery operations and therefore help the decision-making process?

1.3. Goals

The ultimate goal of this thesis is to learn more about visual business intelligence and improve demand-supply chain related processes and information at the case organization to increase transparency and decision-making. To get to the ultimate goal, some milestones are needed to guide the way.

The first milestone is reached when the researcher has created a comprehensive theoretical understanding of the main matters related to this study. Those matters

include the concept of transparency, psychology of decision-making, visual business intelligence (later also data visualization) and demand-supply chain. The second milestone includes communications with different stakeholders in the target organization to get a clear vision of their demand-supply chain. After this the researcher is able to communicate and understand problems and opportunities for improvements in the target organization and suggest solutions based on the theoretical knowledge gained during the first milestone. This is the third milestone. The fourth milestone is reached when the researcher and target organization are both satisfied with the chosen improvement tasks that are to be done in the fifth milestone. The sixth and last milestone is achieved when an implementation plan is build and the feedback of improvement tasks have been collected to verify if there has been any benefits of the development tasks conducted during the study. The goal is reached if the implementation plan is accepted and the measures show increase in productivity, efficiency or transparency.

Table 1. Research milestones and final goal

Milestone 1: Comprehensive theoretical knowledge
Milestone 2: Clear vision of the demand-supply chain in the target organization
Milestone 3: Understanding opportunities for improvements with data visualization
Milestone 4: Selection of improvement tasks to be performed
Milestone 5: Performing improvement tasks
Milestone 6: Implementation plan and measuring the results
Goal: Improved productivity, efficiency and transparency

1.4. Company introduction

The target organization, Valmet Technologies Oy is a leading global developer and supplier of services and technologies for the pulp, paper and energy industries. Valmet Technologies Oy and its +10 000 professionals provide services covering everything from mill production, maintenance outsourcing to mill and plant improvements and spare parts. (Valmet Webpage, 2014) This Master's thesis is done for the whole Valmet Technologies Oy in the pulp and energy business line. Valmet Technologies demerged from Metso Group in December 2013 but its history dates back to the late 19th century (Valmet Webpage, 2014).

After the demerger from Metso, Valmet Technologies has been putting a lot of effort creating "the Valmet way of working" by uniting practices, tools and processes. This

master's thesis project is conducted under this larger goal of unification and improvement. Figure 1 summarizes Valmet's mission, strategy, must-wins, vision and values.

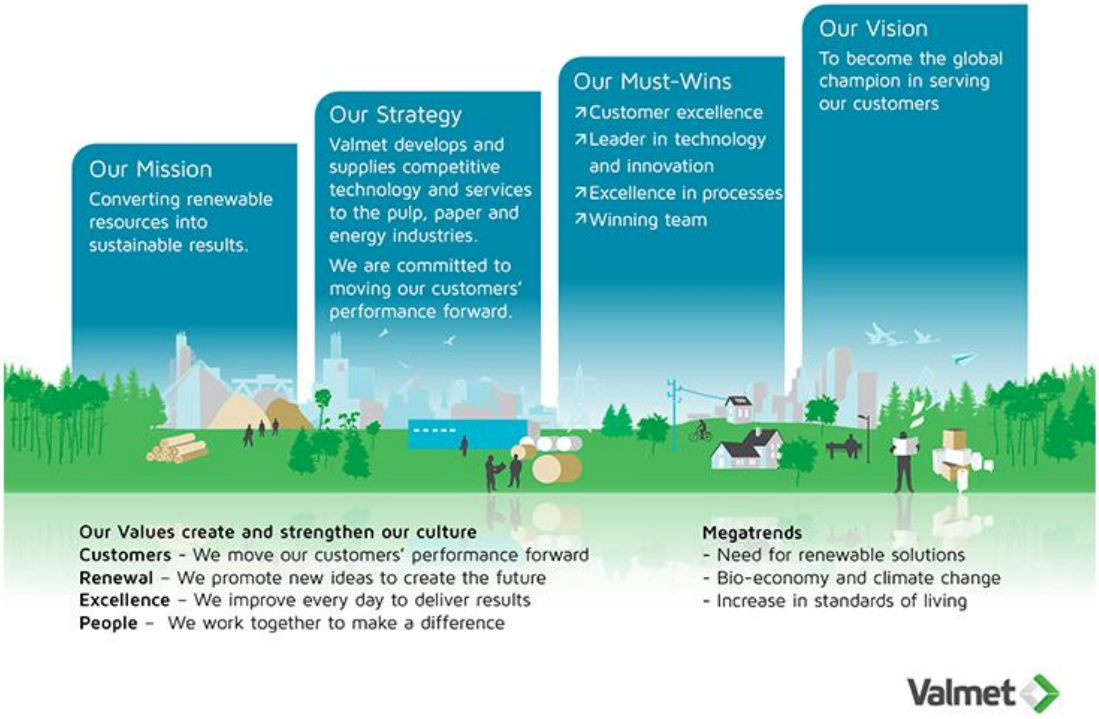


Figure 1. Valmet's way forward (Valmet Webpage, 2014)

The thesis worker has been working under the supervisor of operational excellence function as a business analyst in the data analytics and visualization team participating in business analysis development projects on side with the master's thesis project.

1.5. Research structure

This research is divided into eight chapters starting from this introduction chapter. Following chapters two, three and four include summary of the external analysis done based on scientific literature related to transparency, decision-making, data visualization and demand-supply chain. Chapter five introduces reader to the research design. The research is conducted in two stage process and both stages include multiple steps. According to the research strategy chapters six and seven present taken actions in diagnostic and therapeutic stage. Findings from therapeutic stage are presented in sub section 7.3. Chapter eight includes discussion and conclusions of the whole research and suggestions for further development for the target organization.

2. PSYCHOLOGY OF DECISION-MAKING

Humans make decisions every day. It is usually so natural to us that we do not even notice when the situation is a decision-making situation. In reality, every single decision we make is created by sophisticated machinery in our brains. This machinery develop all the time when we are encompassed by new things and situations. But the system behind our decisions is not perfect. It is prone to misleading behavior, illusions and comfy seeking. To be able to guide our own thinking process and make better decisions we have to know the main ways our own mind tries to trick us into falls interpretations and decisions. (Kahneman, 2011).

Human mind is divided into two systems: system 1 and system 2. System 1 functions automatically and fast without any voluntary limitations and with minimal effort. In other words we cannot control it. System 2 works with the mental actions that need active processing, for example complex calculations. System 1 is always on and requires help from system 2 only when there is a problem that it has not encountered before or is too complex for system 1 to solve. Thus, system 1 is always learning and developing according to surrounding environment. (Kahneman, 2011).

The physical environment is a source of data and the social environment determines what is collected and how it is interpreted (Ware, 2004). This means that the thinking and decision-making is not entirely happening inside our brains. Most cognition is done as an interaction with cognitive tools and increasingly, computer-based intellectual tools and information systems are included in these tools. (Hutchins, 1995). But system 1 is not perfect, it includes systematic errors and biases that make it perform in an illogical way or it makes us answer questions that are easier than the presented ones (Kahneman, 2011).

Neurons in human’s brain provide a pattern-finding mechanism that is an important component in most of our cognitive activity (Ware, 2004). The role of data visualization is to leverage the functioning of the human visual system in an effort to provide insight about abstract information, to help humans resolve logical problems, to think and to reason and to provide assistance in understanding data (Patterson, 2014).

2.1. Decision-making process

Decision-making is usually based on three step process that is presented in figure 2. First step, diagnosis, creates the need for decision-making. It can be an event created by internal change (want), external change (demand) or it can stem from realization that earlier decision has not produced wanted outcomes in the implementation phase. (Beach & Connolly, 2005).

To make sense of the event, decision-maker must put the events to right context to give it meaning. After this he can decide what to do based on previous experience. If the new event is very similar to older ones, his cognitive models created based on previous experience will do most of the work for him and the process is quite straight forward. If the event is different from previous ones the decision-maker has to formulate an action plan to deal its uniqueness. Action plan helps him to interpret the event and the context more thoroughly and it can show him if the problem has been interpreted wrong or the selected framing is false. Diagnosis done based on the action plan shows the decision-maker whether he can make the decision based on his previous experience or, in cases of very unique event, does it require acquisition of new knowledge in order to make the decision. (Beach & Connolly, 2005).

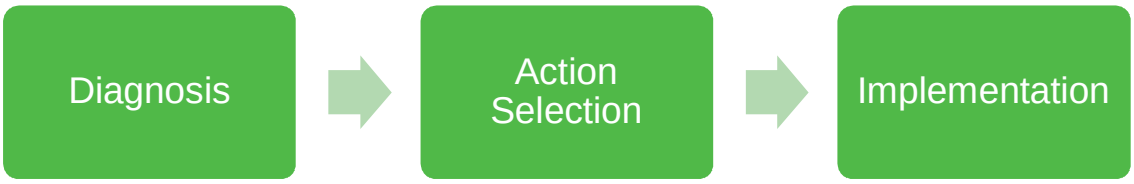


Figure 2. Decision-making process (Adapted from Beach & Connolly, 2005)

Step two is called Action selection even though decisions are seldom made at a single point and usually complex problems cannot be solved by choosing the best option from predetermined set of options. Instead, it is normal to start off in one direction and change directions based on information one finds, feedback he gets and finally ending up to directions that never were imagined in the beginning. But if simplification of the step is needed, we can say that the decision-maker encounters numerous situations in which he has to select actions whether to follow a certain direction or change to another. (Beach & Connolly, 2005).

Why he chooses to follow certain path is explained in Kahneman's (2011) prospect theory. Prospect theory states that people base their decisions on the potential change from old state to new (in other words on wins and losses) instead of the value of final outcome. Concept of risk is very important in this context because it defines the potential of different scenarios. Cambridge online dictionary defines risk as "the possibility of something bad happening" (Cambridge online dictionary, 2014). Probabilities are used to examine which option is most favorable for the decision maker

or his organization (Kahneman, 2011). Usually the higher risk in decision-making process, the more complex and consuming the decision-making process is and the more prone system 1 and 2 are for errors.

Last step is implementation in which the final actions selected are implemented to guide the behavior into new direction and monitored if the actions solve the original problem which started the whole process. (Beach & Connolly, 2005).

2.2. Problems in decision-making

Like was said earlier, system 1 and system 2 are prone to systematic errors and biases that can lead to problems in decision-making situations. Because of the way system 1 interprets things, reflecting them to what it has learned before; humans are often faced with conflicts and illusions. (Kahneman, 2011). Many problems are simply caused because of the way these systems work. Also the ever changing environment around us challenges our decision-making system and is the cause of other problems in decision-making processes. When you think of the complex frame of 21st century business world it is clear that problems can occur in all three steps presented in previous section. Now we will go through some of the possible problems related to decision-making.

Some of the illusions causing problems are visual; like the example shown in figure 3 of men in a corridor; but some of them are cognitive. For example the feeling of familiarity might make one believe that a name they have casually heard few days ago is a name of a famous actor when talking about actors in a movie. This happens because the system 1 creates the familiarity and thus the person remembers hearing the name in some context but does not remember what the context was and therefore connects it to the current conversation – movies. (Kahneman, 2011). This can cause problems in the diagnosis and action selection steps of the decision-making process because the decision-maker can combine the events causing the problem to wrong context, for example. Table 2 summarizes some of the features of system 1 presented by Kahneman (2011) that can affect our decision-making process.

Table 2. Features of system 1 affecting our decision-making (Adapted from Kahneman, 2011).

Feature	Explanation
Produces impression, feelings and tendencies	Which can lead us to diagnose events based on these feelings etc.
Automatic, fast, no need for regulatory or efforts	Prone to errors when in stress because we are not actively controlling what system 1 does
Unites the feeling of cognitive ease to illusion of truth, pleasant feelings and lowered alertness	Easiness is a sign to our brain that everything is good, which might not be true
Separates unexpected from normal	Directs our attention to the unexpected and the "normal" is left with less attention
Halo effect	If something is thought to be good, system 1 requires double the bad to believe it to be bad (for example a police man seen committing a crime can be interpreted as doing a undercover tasks not an actual crime)
WYSIATI (what you see is all there is)	Decisions are sometimes made based on options given and not even thought that there might be an solution outside of those options
Anchoring influence	When some sort of starting point is given in problem solving situation, this starting point has an effect on the solution

All of the features presented in table 4 are cognitive errors. But some of the errors can be visual. Figure 3 shows how easily our visual interpretation can be misled. System 1 creates three dimensional image of the two dimensional picture of men in a corridor because it is more used to handling three dimensional data and the lines on the wall makes an illusion of a horizon.

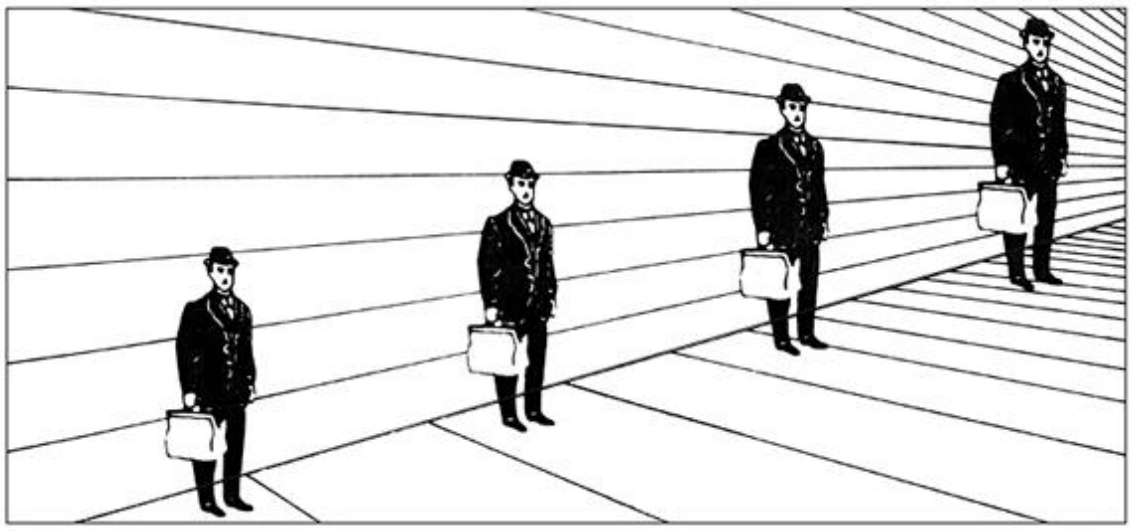


Figure 3. Visual illusion. The man on the right seems larger than the man on the left but they are actually the same size. The horizon causes the misinterpretation. (Roger, 2001)

The tests Kahneman (2011) presents in his book show how people make hasty conclusions when the system 2 is under strain (cognitive distress). For example in one test the system 2 was loaded with irrelevant tasks while hearing false statements. Because the system 2 was not able to assist system 1 with the statements, the test subjects thought that the statements were right instead of false. System 1 is distorted to think that system 2 takes care of the questioning and misbelieving but sometimes the system 2 is busy or lazy and therefore unable to perform its tasks.

System 2 can also be misled with so called anchoring influence. This refers to an influence that, for example, an asking price of a house creates. According to studies conducted by Kahneman (2011) when a person is firstly lead to think about a certain figure; he is more prone to choose his answer according to the thought figure instead of thinking and inventing the figure from scratch. An example clarifies. When Kahneman asked from one study group if Mr. Gandhi was over or under 144-years old and from another group if Mr. Gandhi was over or under 35-years old, the first group guessed Mr. Gandhi to been a lot older than the latter group. The results showed that the age used in the question influenced their answers.

As was said earlier, surrounding environment and the context we put and in which we study the events affect decision-making as well (Beach & Connelly, 2005). A large influencer is the availability of information. Information is often limited and it can be processed and created for a certain context. These are all issues that can create problems in the diagnosis step of decision-making process.

The availability of information also links to some features of system 1 presented in table 2. For example with WYSIATI (what you see is all there is) the information available is the base for this bias. We also often think that an issue is far more common than it actually is if it has been shown to us one or repeatable times lately or it verifies the

cognitive maps we have created in the past. This may lead to a situation in which a company CEO has lately succeeded in decisions and thus considers success more likely than failure in the future. In reality he might get too confident to his abilities and fail. (Kahneman, 2011).

We create our opinions based on the information available. But if the information we get changes, so that it changes our opinions, it overwrites the old opinion with the new one. This might create problems in decision-making situations because it is difficult to remember the reasoning behind the old opinion and thus the information is unbalanced. (Kahneman, 2011).

To improve decision-making, organizations have to improve transparency of their processes and data. That been said, for organizations, the two most important issues to develop in, in relation to decision-making, are 1) obtaining, filtering and verifying the necessary data needed for decision makers and 2) understanding how human beings fit into the decision-making process (Badami, 2009). Organizations have started to use Business Intelligence tools among other information systems to tackle the first issue. The future transformation of the decision-making process is yet to be tackled in many organizations.

As has been told, many cognitive and visual issues affect humans' decision-making process; communication between system 1 and system 2, visual cues, cognitive maps, context, information available, concept of risk and so on. The list could be broadened by continuing to problems caused by social encounters in group decision-making or problems caused by cultural background and so on.

2.3. Transparency in decision-making

Transparency is not an unambiguous term. Transparency has a variety of different meanings depending on the situational context (Simon, 2006). It can be either internal or external (Street & Meister, 2004). External transparency refers to the transparency organizations create with outsiders by sharing information concerning their business activities (Street & Meister, 2004). This type of transparency is usually required in some extent by the legislation of countries and more and more by the consumers' desire to know what organizations do and how they do it. Internal transparency corresponds to same behaviors than external but it happens inside the organization (Street & Meister, 2004). It is also considered to be an outcome of communication behavior (Street & Meister, 2004).

It is important to notice that situational context creates the surroundings in which transparency's meanings are irreconcilable and therefore can be misleading. When talking about transparency from financial or governmental perspective or with a cultural component, the signification of transparency gets different levels and forms (Simon,

2006). According to one definition, often used in information management studies, transparency can be thought to be forms of information visibility that can be increased by reducing or eliminating obstacles. In this case - transparency usually refers to the accessibility of the information (Turilli & Floridi, 2009); and especially in business environment - the amount of information in which decision-makers base their decisions on (Winkler 2000).

Therefore when talking about business environment, the concept transparency is usually linked to the process of decision-making through explicitly and openly available information (Turilli & Floridi, 2009). In this thesis, transparency refers to organization's ability to see its processes and actions over all business lines and to its ability to base its decisions on reliable data in the organization.

Table 3. Definition of transparency used in this master's thesis

***Transparency**:* Organizations and its employees' ability to: 1) See processes over all business lines 2) Base decisions on reliable data

Information systems have a major role in creating transparency. For many companies, especially international ones, information systems enable communication and information sharing between employees in different locations (Street & Meister, 2004).

Berggren and Bernshteyn (2007) have determined four levels of transparency (presented in table 4) in which extent strategy can be communicated to employees. These four levels can be used to describe the internal transparency in other aspects as well. The first level describes an organization in which transparency is basically non-existing. Employees are put to perform their tasks without the understanding of the overall purpose of those tasks. Second and third level transparency is more common than level one. Second level transparency, in which strategy is interpreted liberally amongst organizational executives, can usually be seen in large multi-industry organizations where different business lines can vary greatly from each other. In third level transparency the transparency is satisfactory on certain hierarchical levels of the organization but usually the lowest performing level is left out. This is a problem large companies face. When employees in front line, providing customer service for example, are far away from the management and executives, the implementation of strategy or common ways of working might not reach the front line in sufficient amounts and forms. (Berggren & Bernshtey, 2007).

The fourth level of transparency is currently most wanted in organizations. In fourth level transparency, each individual employee knows and understands how his work and tasks connect to the organization's strategy because these issues are communicated

effectively and broken down into actionable goals for each and every one. According to Berggren and Bernshtey (2007) this type of transparency creation is especially beneficial when organizations have to make strategic shifts. In hard times like strategic shifts, the organization has a clear image of the talent pool it has and their abilities to attract or to develop needed skills. (Berggren & Bernshtey, 2007).

Table 4. Four levels of transparency by Berggren and Bernshtey (2007)

Level of transparency	Characteristics
1st level (non-transparency)	An organization does not reveal its strategy to its own employees
2nd level	Ambiguous strategy that is interpreted liberally by organizational executives (strategy is known and understood only in one's own work context). Overall business strategy is not coherent.
3rd level	An organization has a clear strategy that is understood widely in the executive level. The integration to lower levels of the organizational hierarchy is inadequate.
4th level	Organization's strategy is clearly communicated and broken down into actionable goals to each employee.

Like was mentioned earlier, these four levels of transparency are created for evaluation of the strategy transparency but they include very important factors when considering other types of transparencies in organizations. In all internal and external transparency it matters how the transparency is equally distributed and understood in different hierarchical and operational levels.

Internal transparency is a mediator between communication behaviors and outcomes such as planning ability or decision-making (Street & Meister, 2004). And decision-making is at the core of all business activity (Badami, 2009). According to Badami (2009) decision-making has enormous ability and need to improve both in terms of efficiency and quality to keep up with an increasingly competitive global business environment.

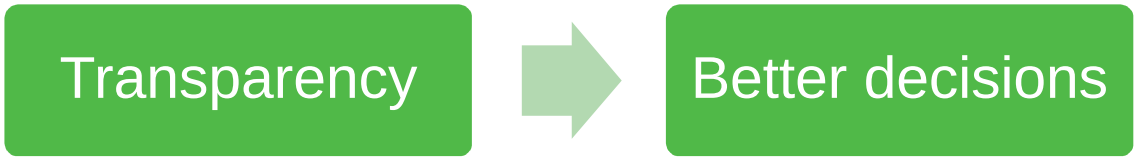


Figure 4. Transparency leads to better decisions

So the objective of transparency improvements is to enable better decisions. Next chapter will tell more about the demand-supply chain surrounding in which transparency and decision-making are examined in this thesis.

3. DEMAND-SUPPLY CHAIN

This thesis research is limited to include only target organization's demand-supply chain related operations and especially operations related to sales and delivery. This chapter presents what demand-supply chain consist of based on scientific research material and it also presents how and why it has born.

Little more than 30 years ago, Oliver and Webber introduced the term "supply chain management" (Christopher & Ryals, 2014) to the business world as a term to describe the function of managing the whole end-to-end chain from purchasing and production to sales. Shankar (2001) defines supply chain management (SCM) as a set of actions associated with the flow and transformation of goods, information and financials from the raw-material stage all the way through to the end user. It is a set of organizations, business processes and human resources supported by information management and physical infrastructures (Lyons et al. 2012, p. 114). A typical supply chain is a collaboration of component and materials' providers, production plants, distribution facilities, retailers and consumers joined together by the downstream flow of materials and credit and the upstream flow of information and money (Lyons, et al. 2012).

But because the term supply, refers to the production side of the chain, supply chain management grew up to be "push" ie. production oriented instead of demand-driven "pull" (Vehlhaber, 2000). Since then, many supply chain management practitioners have revolved around low-cost manufacturing and production efficiency instead of delivering superior value in the marketplace. Also the time, during which supply chain management spread amongst industries, was favorable for production-driven perspective since the economy was quite stable, the prices of materials were believed to stay low for a long periods of time. This led the management to make decisions for longer periods of time (Christopher & Ryals, 2014).

Specific interests and activities in the supply chain usually include sourcing and procurement, product design, production planning, material handling, order processing, inventory management, transportation, warehousing and customer service (Shankar, 2001). Supply chain activities can be divided into three categories according to their decision levels: Strategic, tactical and operational (Lyons et al. 2012). At the strategic level activities are related to network design and optimization, partnership formation, information technology and make-or-buy decision-making. In tactical level activities concern supply contracts, demand and production planning and sourcing. Activities left for the operational level usually include production scheduling, manufacturing, distribution and inbound/outbound operations. (Lyons et al. 2012).

3.1. Demand driven supply chain

Times have changed since the introduction of supply chain. Resources are getting scarcer and technology cycles faster and faster (Cristopher & Ryals, 2014). The rising prices of resources have led the companies to start seeing their business from the demand perspective in order to optimize their functions and minimize obsolescence in the whole end-to-end chain. Globalization has united the geographical market areas introducing new opportunities but also new competitors (Lyons, et al. 2012). This all has led to a situation in which companies cannot predict the future and especially the fluctuation of demand and supply anymore (Tomlin, 2014). In industries with very expensive capacity – like automobiles, engineering products and aerospace, this produces a major risk (Tomlin, 2014).

To keep up, organizations have turned to be more customer oriented and their supply chains are becoming more and more customer driven "pull" instead of "push". Customer (demand) driven supply chain has synchronized planning activities and is capable of consistently operating with small-batch, high-variety production and distribution providing customized items in single units at an efficiency level that can be compared to a mass production environment (Lyons, et al., 2012). In demand driven supply chain, customer relationship management (CRM) as a part of marketing functions is a crucial part of the chain. Marketing in general strives to understand consumer needs, satisfy them and continuously add value. CRM is a business process which's goal is to create, enhance and manage customer equity – that is, the value of customers to the company. This is achieved by interacting with customers using different channels. (Shankar, 2001).

With the help of Internet and other information tools customers and businesses are more global and more 24/7 than in the past century. Organizations have more channels to interact with their customers and collaborate with them in design and innovation of new solutions (Christopher & Ryals, 2014). And because customers can shop anything online, from nail polish to power station - globally, anytime of the day, responding to demand and creating customer value has become more vital (Christopher & Ryals, 2014). In the future additive manufacturing (3D printing for example) is most likely to guide the power even further to the consumers and demand side of the chain (Christopher & Ryals, 2014).

Demand-supply chain management is a group of tasks to achieve simultaneous excellence in customer relationship management and in supply chain management (Shankar, 2011).

Figure 5. Definition of demand-supply chain management.

Figure 6 highlights the core difference between supply and demand oriented systems. Both of them are three-stage systems and both of them include large variety of functions

but demand system starts with the opportunity identification whereas supply system ends to it. In demand system, customer insight is used to identify opportunities by examining customers' values. When customers' desired values are identified the organization can select a suitable target and define the benefits that justify the target. The next stage is for providing the value which include the typical supply chain processes of product and process designs, procurement, manufacturing and distribution. In the end of demand chain the value is communicated to the customers and other stakeholders through pricing, sales messages and advertisement as well as through promotion and PR. (Christopher & Ryals, 2014).

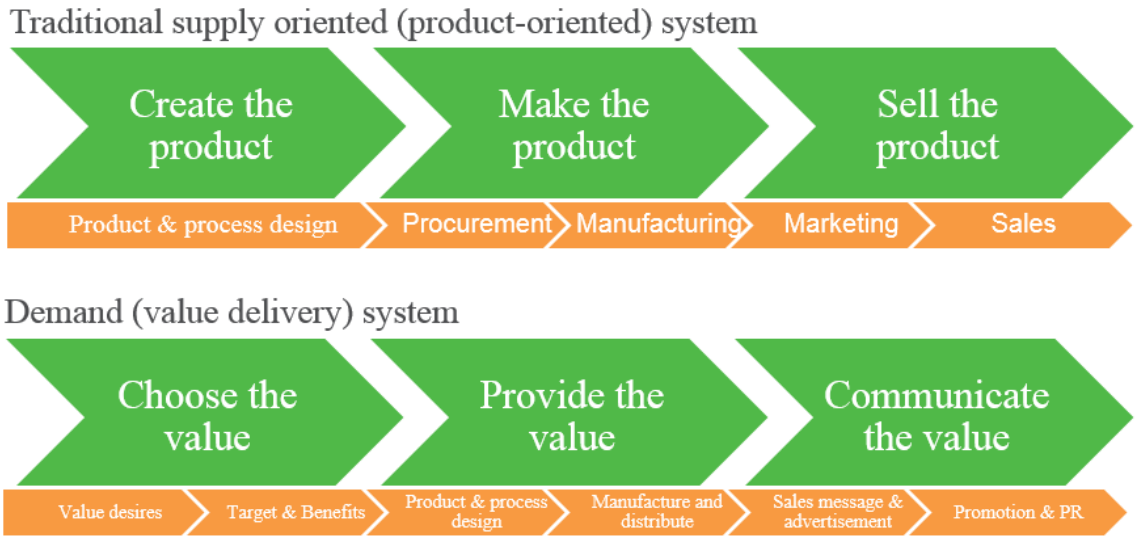


Figure 6. Difference between supply and demand oriented systems (Adapted from Christopher & Ryals 2014)

One major problem large organizations can face is that the customer needs are answered and the value created on a local level but global objectives of the organization are neglected (Lyons et al. 2012, p. 113). Enterprise modelling can help managers to understand the complex and dynamic nature of their organization and its demand-supply chain and it can help them to create new solutions to improve their performance (Lyons et al. 2012, p. 113).

Three basic topologies exist that can help managers to understand their demand-supply chain. A hierarchical demand-supply chain is one in which an original equipment manufacturer acts as the central company. (Lyons et al. 2012, p. 114). Other structural aspects of a hierarchical demand-supply chain are that all the demand-supply members are indirectly or directly connected to the central company through their suppliers or customers and that the structure of the network can be defined by the levels of transformation in horizontal way and by the number of suppliers or customers at each level in the vertical structure (Lyons et al. 2012, p. 114). Figure 7 demonstrates case corporation's demand-supply chain from its perspective.

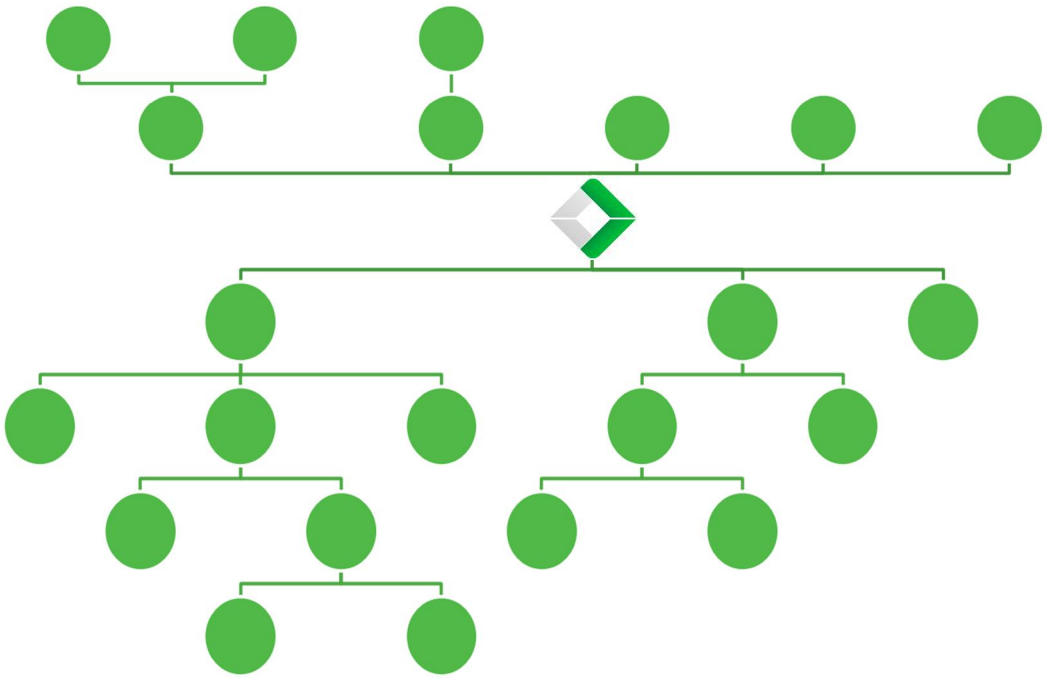


Figure 7. Example topology of demand-supply chain in which the case corporation is the link between customers on top and subcontractors, partners and suppliers below.

In sequenced demand-supply chain all participants are in line to one after another with no other linkages. In today's complex business environment this type of topology is rare.

Networked demand-supply chain differs from hierarchical in so that it does not have one central company for the demand-supply chain. The prevailing central company changes depending on which part and level of the demand-supply chain is examined. The structure of networked demand-supply chain is complex to simulate because it is very dynamic (Lyons et al. 2012). As a comparison figure 8 shows the same chain but from the perspective of electric company of Tampere (red and blue logo). From this perspective the case corporation is one provider of technology to a company producing energy (Fortum in the example). That energy producing company sells their energy to the electric company and can buy solutions from multiple case corporation-level companies whose suppliers provide their services to the case corporation and other companies (shown with red lines). In the end the electric company sells electricity to multiple companies that can also be on a lower hierarchical level of the demand-supply chain. This is how the networked chain starts to form. This figure 8 shows how changing the central company, changes the whole chain and how organizations are linked together.

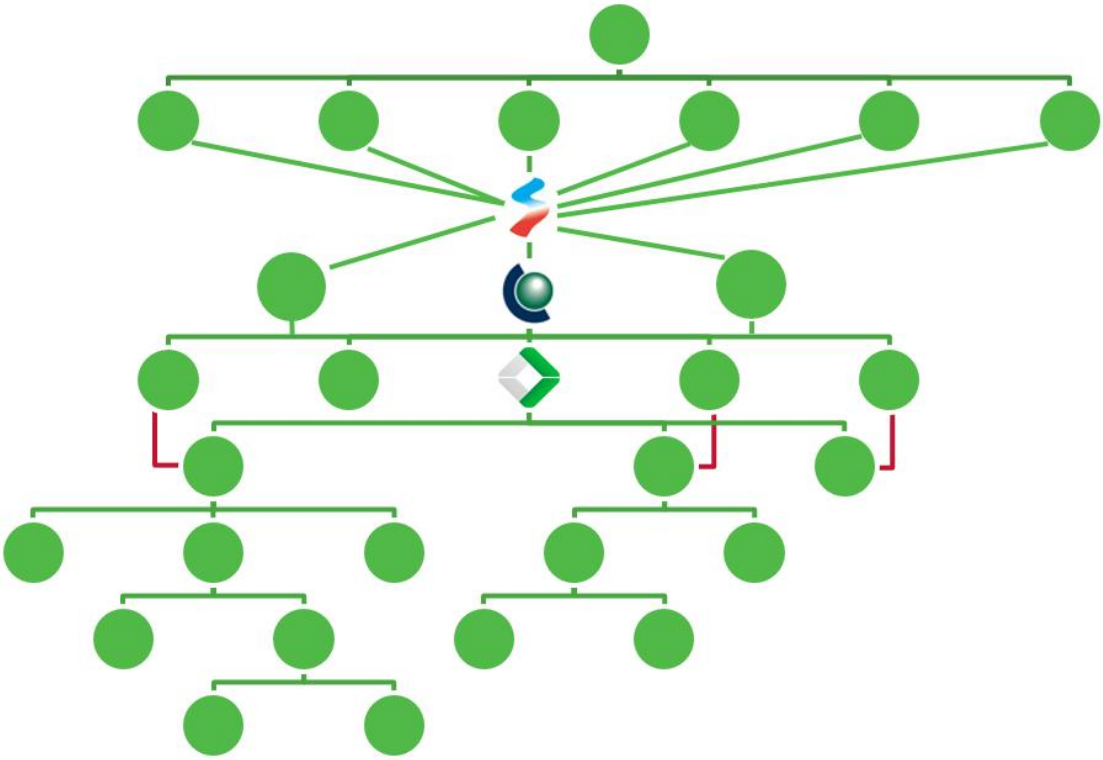


Figure 8. Networked and hierarchical demand-supply chain in which the case corporation is a part of.

Still often demand and supply chain are individual bodies in large organizations like the target organization. This is due to the massive size of them with thousands of subcontractors, suppliers, internal functions and locations and customers. These massive demand and supply chains create massive amount of data that could be utilized in data visualization. Integrating supply and demand chains can create competitive advantage for companies (Shankar, 2001). This way functions in different parts and ends of the chain can advantage more on each other's knowledge. Information and communication technology (ICT) have been used to minor this gap between the ends (Nair, 2015). It has resulted in greater agility, robustness, collaboration, transparency and seamless integration with all stakeholders in the demand-supply chain inside and outside of the organization (Nair, 2015).

3.2. Demand-supply chain planning

When planning customer-driven supply chain – four wide-ranging objectives apply – the elimination of waste, the alignment of production with demand, the integration of suppliers and the holistic and innovative involvement of the workforce in process improvement activities (Lyons, et al. 2012). Ultimate goal is to create flexibility (Tomlin, 2014). Flexibility is needed in all functions whether it is related to product design, process design, production technology or people, the whole network of the organization needs to be flexible (Tomlin, 2014).

The role of information systems in supporting customer-driven supply chains is vital. With information systems, data of demand and production can be shared across the demand-supply chain to ensure that the customer and supply chain behavior are transparent to decision-makers. Good information systems ensure the flow of useful real-time accessible data. These information systems and data only create advantage if the people and processes of the organization are agile enough to actively react and change according to the ever changing data and environment (Lyons, et al. 2012).

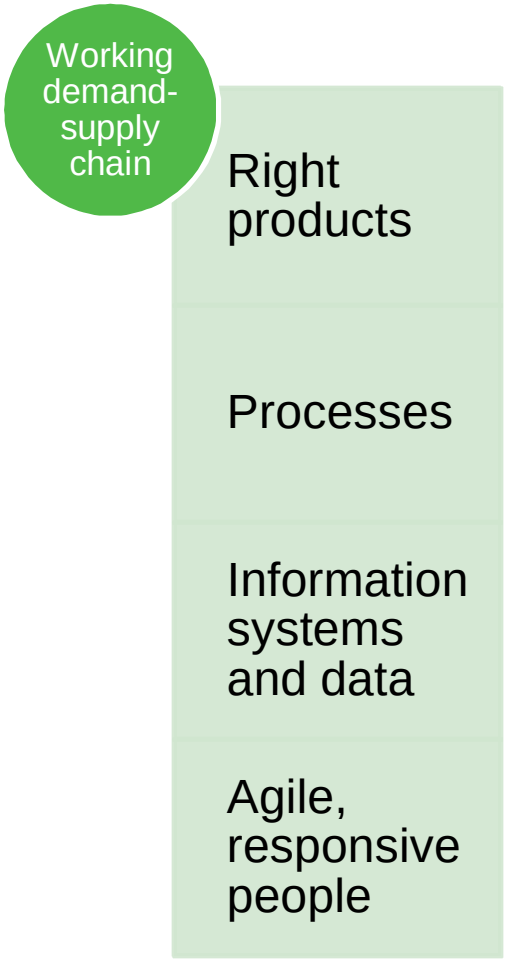


Figure 9. Building blocks of working demand-supply chain

Demand-supply chain planning can benefit from ICT and business intelligence in several processes in demand-supply chain planning and execution like demand forecasting, inventory management, and production and distribution planning (Nair, 2015). Still some challenges exist: visibility and transparency of DS chain planning and execution, accurate demand forecasting, high costs of ICT and business intelligence solutions, costs overruns in DSC and data aggregation from multiple sources (Nair, 2015).

4. VISUAL BUSINESS INTELLIGENCE - DATA VISUALIZATION

Data visualization is business intelligence in a visual form. According to Evelson (2008), “Business Intelligence is a set of methodologies, processes, architectures, and technologies that transform raw data into meaningful and useful information.” This is done so that the workers and managers would be able to make better business decisions (Obeidat, M. et al, 2014, p. 127). Business Intelligence is used as an umbrella term (usually from the information technology perspective (Sircar, 2009)) to describe wide variety of concepts and methods from the fields of Business Analytics, Market Intelligence and Competitive Intelligence (Chen et al., 2010, p.201).

Information created by business intelligence methodologies and technologies is consumed in a variety of ways (Pourshahid et al., 2014). Managers can interact directly with a system, viewing data presented in reports or they can have analysts to provide ready reports to them (Negash, 2004). Also dashboards are created and used to see quick review of performance against targets (Pourshahid et al., 2014). One of the new ways to interact with company data is on-line analytic processing (OLAP) that enables managers to dynamically interact with the data using dimension such as customer, location and product (Pourshahid et al., 2014).

Even though the most important goal of business intelligence is to enable informed decision-making that drives to improved organizational performance (Vinekar et al. 2009) more than 50% of business intelligence implementations fail to influence decision-making process in any meaningful way (Ko & Abdullaev, 2007; Pourshahid et al., 2011). This might be due to the lack of integration of business intelligence into the decision-making process (Ko & Abdullaev, 2007). According to Vessey (1991) more effective decision-making results, when the decision aid supports directly the decision task. In other words a cognitive fit has to form between the problem representation (i.e. the way data is presented by the business intelligence tool) and the cognitive task (i.e. the way data is used) (Pourshahid et al., 2011). If the integration is done successfully business intelligence can give valuable data support for the decision-makers but only if data is available, correct and presented in a proper context (Pourshahid et al., 2014). In other words, the data has to be transparent.

4.1. Background

Humans are visual creatures (Burn-Murdoch, 2013), majority of our brain's activity deals with processing and analyzing visual images which are usually processed before text (Burkhard, 2004). Also, we consume less energy when we are processing visual images than text (Burkhard, 2004). Ultimate goal of data visualization is to move information processing from the active thinking process (system 2) to the visual observation system (system 1), which works unconsciously in the background (Paukkeri, 2014). By easing the information processing with visually presented data we should be able to enable decision-makers more effective decision-making process by creating better cognitive fits between presented data and decision-makers' cognitive tasks (Patterson et al 2014).

Colin Ware (2004) writes in his book "Information Visualization: Perception for design": "The eye and the visual cortex of the brain form a massive parallel processor that provides the highest bandwidth channel into human cognitive centers. Higher levels of processing, perception and cognition are closely interrelated, which is why the words *understanding* and *seeing* are synonymous." Our brains are wired to process information better in a visual manner (Simon, 2014).

Terminology for visual business intelligence is very messy and overlapping with labels like visual business intelligence, data visualization, visual analytics, data discovery, data mining and so on. Visual business intelligence is mostly used in corporate environment while data visualization is more common in academic societies. In general, most common terms are 'Data Visualization' or 'Visual Analytics'. Table 5 summarizes search engine hits for these three terms. In this thesis visual business intelligence is thought to be the umbrella term for data visualization and visual analytics. I will use the term 'data visualization' because it is the term mostly used in the reference material.

Table 5. Search engine hits with three different search terms

	Google Scholar	Nelliportaali: Articles	Science Research
"Visual business intelligence"	159	156	42 498
"Data visualization"	141 000	4 960	315 508
"Visual analytics"	13 100	3 517	54 392

Nykänen (2014) says that data visualization includes two parts that are scientific (data) visualization which means the interactive and analytic attempt to visualize data in 2D/3D with scientific computing or measurements – and information visualization which complements scientific visualization by extending the visualization to more abstract or arbitrary systems like data structures or hypermedia databases. Data visualization can refer to the technical process of visualization as well as to the end product of the process. (van Wijk, 2005) In this thesis, visualization is used to refer to both the process and the end product.

Like was mentioned, the terminology is not in its clearest form. Some researchers question the difference between reporting tools, analysis, data visualization, business intelligence and other information related terms (Simon, 2014). Table 6 lists some of the differences between traditional reporting tools, analysis and data visualization according to Simon (2014). The most important notion from this table is that data visualization should not be considered as a readymade answer to predetermined question. Its power is in allowing users to interactively ask ever deeper questions that rise while examining visualized data. Of course with ambiguous term as data visualization there are also exceptions like infographics which are presented later in this chapter.

Table 6. Reporting vs. Analysis vs. Data Visualization (Adapted from Simon, 2014)

Traditional Reporting Tools	**Analysis**	**Contemporary Data Visualization Tools**
Provides data	Provides answers	May provide answers. Allows users to ask deeper and arguably better questions of data.
Provides what is asked for	Provides what is needed	May provide what is needed
Typically standardized	Typically customized	Extremely customizable; interactive data visualization enables each user to discover vastly different things
Does not involve a person	Involves a person	Involves a person; data visualizations are subject to interpretation
Is fairly inflexible	Extremely flexible	Depending on the data visualization can be extremely flexible or not (infographics)
Handles small data	Handles small data	Can handle both small and big data

Now that the terminology is little bit clearer it is important to clarify what data visualization actually means. Before, the term ‘visualization’ meant constructing a visual image in the mind (Shorter Oxford English Dictionary, 1972). From this internal construction of the mind the term has developed, mainly due to the development of usable tools, into more like a graphical representation of data and concepts that are external artifacts used to support decision-making (Ware, 2004). Visualization is the process of representing data as a visual image (Latham, 1995). Data visualization helps users to understand mass data by presenting it in a visual form (Baltzan, 2013; Illiinsky & Steele, 2011; Rodeh, et al. 2013; Ware, 2004). It is the graphical display of abstract information for two purposes that are sense-making and communication (Few, 2014).

With visualization, one can communicate complex information, help understand complicated relationships between multiple variables, uncover information hidden in the data, and solve problems through visual representation in the form of data structures for expressing and sharing knowledge (Sackett et al. 2006). Card et al. (1998) phrase that the visualizations are computer-supported, interactive representations of data to amplify cognition. According to Alazmi & Alazmi, (2010, p. 297) data visualization is an emerging field, that is developed to tackle the ever-increasing growth of size and complexity of databases. These definitions show that data visualization is

1) Created using computer-supported tools
2) Based on data
3) Created to support problem solving and decision-making
4) Using humans’ most developed sense to convey information
5) Used as a support tool for inter-human communication

The next section demonstrates how much visualization can help in interpreting data with one simple example. After that some most common visual clues are presented. Section 4.3. talks about the difference between data, information and knowledge in relations to visualizations. After that four different visual business intelligence tools are presented that epitomizes static and dynamic visual business intelligence tools. Section 4.5. shortly explains why data visualizations are used in organizations and paragraph 4.6. lists more thoroughly characteristics that affect decision-making in the three steps of decision-making process (explained in chapter two). To understand how data visualizations are usually created, section 4.7. explains the process briefly. The last section sums up what the reference material considers to be the future for data visualization.

4.2. Visual clues

Figures 10 and 11 present an example how much visualization can affect our abilities to acquire information and make interpretations of it. Figure 10 shows an excel table of data related to population growth of largest cities in countries with GDP per capita

above $10 000 U.S. dollars. Figure 11 shows a visualization of that data. Visualization represents 40 cities that are estimated to be the most densely populated cities in 2025. The size of the circles represents density in 2025 and the deepness of the green color shows how fast the population growth will be between 1995 and 2025.

Data presented in a table form can answer questions that are not too complex. For example which city will be the most populated in 2025, or does Mexico City or Salvador grow faster between 1995 and 2025? But when questions become more complex the difference between the speed of insight formation from data table and data visualization become obvious. Questions like which geographical area has the biggest amount of densely populated cities or what are the top three cities in terms of density of population or the growth rate; can be answered thoroughly in seconds based on the visualization but based on the data table it would take longer time or in some cases might not even be possible. Visualization also highlights interesting facts about the data set that lead the viewer to examine those facts closer. For example in figure 11 the viewer might wonder why population growth in the U.S. has been fastest in Atlanta and Phoenix. What is happening in those cities that make people move there or is it due to higher birth rates? Through these new unexpected questions the viewer might form insight that he was not even anticipating to create.

Of course it is worth mentioning that also the data table is one form of visualization. If the information presented in the table would be divided into separate papers or webpages or they would be read to the user, answering previous questions would be even harder or even impossible.

Most Crowded in 2025: Global Cities

123 Numeric View | Bar View | Information | Read the Story

Rank	Global city, country	Population per square mile 2025 ↓	Population per square mile 1995	Estimated 2025 population (000)	Population growth in one generation, %
1	Hong Kong SAR, China	76,985	57,965	8,160,447	32.8%
2	Salvador, Brazil	38,643	19,588	5,216,832	97.3
3	Mexico City, Mexico	30,726	21,013	24,580,942	46.2
4	Sao Paulo, Brazil	21,068	14,498	23,174,743	45.3
5	Singapore, Singapore	20,867	12,524	5,801,022	66.6
6	Guadalajara, Mexico	19,579	11,829	5,677,822	65.5
7	Brasilia, Brazil	18,974	8,682	4,933,286	118.6
8	Santiago, Chile	18,655	13,064	7,088,879	42.8
9	Rio de Janeiro, Brazil	17,463	13,044	13,621,289	33.9
10	Jiddah, Saudi Arabia	16,067	6,769	5,221,695	137.4
11	Monterrey, Mexico	15,915	8,582	5,490,526	85.5
12	Madrid, Spain	15,878	9,192	8,097,731	72.7
13	Barcelona, Spain	15,688	10,584	6,510,595	48.2

Figure 10. Example data table related to visualization in figure 6 (Bloomberg, 2014).

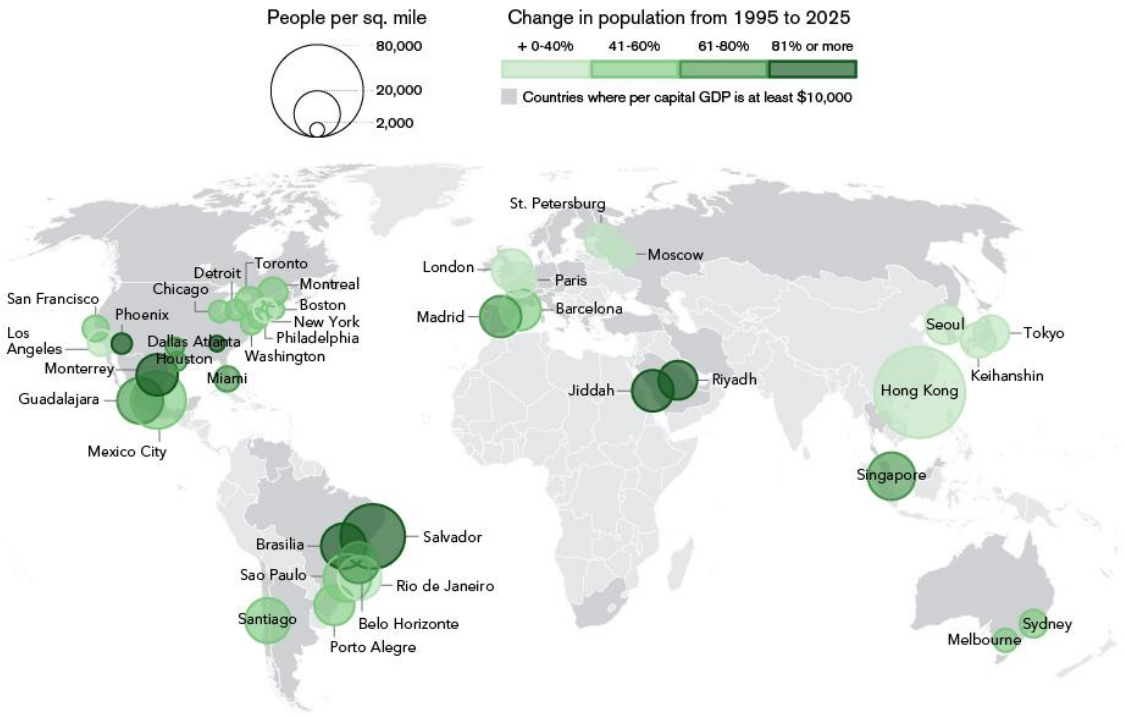
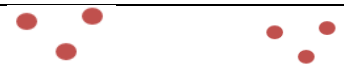
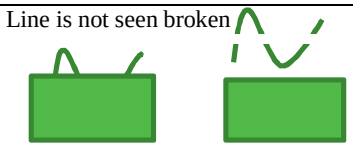
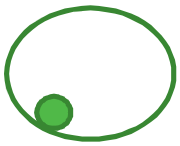


Figure 11. Visualization of the fastest growing cities in countries with GDP per capita above $10 000 U.S. dollars (Bloomberg, 2014).

But not all visualizations are equal. Humans understand different types of visualization better than others (Simon, 2014). Study, conducted by Cleveland and McGill (1984), showed that people understand different graphical representations with variable skills. They listed visual clues according to how accurately people can decode them. Visual clues that were the easiest to decode were for example position along a common scale, length, angle and area. Few (2014) recites that some of the principles of perception are discovered as early as 1912. These principles are still today accurate descriptions of our visual behavior. Some of them are listed in table 7. Ware (2004) adds symmetry and relative size to the principals. Bertin (1983) simplifies that notable graphical symbols and marks affecting humans' cognitive systems are position, shape, size, brightness, color, orientation, texture and motion. Good visual representations try to follow these principles (Fekete et al. 2008).

When creating visual business intelligence tools, it is very important to knowledge these principals of perception to be able to create tools that follow user's cognitive processes and therefore support him in decision-making.

Table 7. Principles of perception (Adapted from Few, 2014 and Ware, 2004)

Principal of perception	Explanation	Example
Proximity	Objects that are close together are perceived as a group	
Similarity	Objects with similar attributes (shape, color) are perceived as a group	
Enclosure	Objects that seem to have a boundary around them	
Closure	Open structures are perceived as closed, complete and regular when there is a way to reasonably interpret as such	
Continuity	Objects that are aligned together or appear to be continuation of one another are perceived as a group	
Connection	Connected objects are perceived as a group	
Symmetry	Symmetrically arranged elements are perceived as a whole	
Relative size	Smaller elements of a pattern are perceived as objects whereas large ones as background	

4.3. Concepts of data, information and knowledge and their connection to visualization

Until this point, we have only discussed about data-type of information. We have spoken about data transparency and data visualization. But actually information is divided into three categories; depending on the type of information it gives – the type of questions it answers. These three concepts of data, information and knowledge are the basic building blocks of the field of information science (Zins, 2007) in which this thesis also falls into in a way. Information science is the interdisciplinary science that investigates the use and processing of information for optimal storage, retrieval and dissemination (Borko, 1968). The concepts of data, information and knowledge, are

interrelated and the nature of their relation is debatable likewise their meaning (Zins, 2007). Due to the limitations of this thesis (presented in section 5.1.) it is uncalled-for to closely examine this labyrinth of terminology. Data, information and knowledge are determined only on level that is required in order to understand their effects to the visualization process and outcomes.

Data is basic individual symbols of numeric or other information that without context does not inform anything. When data is connected to other data; by for example naming it, the data is put into a context and information is created. (Zins, 2007). So the difference between data and information is mainly functional, not structural (Ackoff, 1989). At this point data becomes useful. Knowledge requires human participation to interpret data or information. (Zins, 2007). Next table 8 summarizes the definitions of these three concepts: data, information and knowledge in two different spaces. Based on the definition in computational space we can determine their purpose in the visualization process.

Table 8. Data, information and knowledge in perceptual and cognitive space according to Ackoff (1989) and in computational space (Chen et al. 2009)

Category	**Definition in perceptual and cognitive space**	**Definition in computational space**
Data	Symbols	Computerized representations
Information	Data that are processed to be useful, providing answers to who, what ,where and when questions	The result of computational process such as statistical analysis or meaning assigned by human being
Knowledge	Application of data and information, providing answers to how questions	The result of computer-simulated cognitive process such as learning or reasoning or a transcript of knowledge acquired by human being

Data visualization is always based on symbols – numbers, letters, lines; the first level of information forms. When these symbols can be interpreted as words, figures and other meaningful things – we are dealing with information. (Bellinger, et al. 2004) Thus information and knowledge can be used as assistant in the visualization. Like their computational definition determined, information and knowledge can be created (to some extent) in computational process or it can come directly from human beings either in the development phase of the visualization or in the interpretation of it. Chen et al. (2009) talk about information-assisted and knowledge-assisted visualization. With them,

a part of the visualization interpretation process can be automated to enable more effective and efficient decision-making process (Chen et al. 2009).

4.4. Visual Business Intelligence Tools

Visual business intelligence tools support and improve the decision-making process of business managers in different functions and organizational levels (Morrison, 2006). Visual business intelligence tools are an effective way to analyze data because they allow the user to analyze existing data but also helps to identify potential new opportunities by revealing 'gaps' in data (Morrison, 2006).

Many data visualization techniques and tools exist but some of them face the problem of too data-driven instead of user-driven approach. Data-driven techniques may become obsolete in some cases when the information requirements of the user change and the tool is unable to provide the newly needed content. (Morales-Chaparro, et al., 2011)

Data visualization tools can be divided into static and dynamic techniques and more precisely to three different activities that are display/snapshot reporting, operational alerting and visual discovery and analysis (Stodder, 2013). Static data visualization, for example display and snapshot reports, is usually created for a certain purpose – to communicate fiscal information every quarter, identify changes between snapshots or to educate employees about a new strategy (Stodder, 2013). Tools for static data visualization are Excel charts and infographics - to name a few. Visual discovery and analysis are dynamic techniques for data visualization.

Next sub sections present four different types of visual business intelligence tools – two static techniques and two dynamic ones. These techniques were selected as examples due to their general popularity and wide representation of data visualization. These are also tools that are used in the target organization excluding the last one – coded data visualization. Because the field of data visualization is still a growing market, there are a large amount of different data visualization tools ranging from tools created by the mega corporations like IBM, Microsoft and SAS to small start-up companies like Lemonly or Hahmota. It has to be pointed out that because data visualization can be used in such many ways, many companies choose to use multiple tools to do that. It is probably impossible to find just one tool which could satisfy all visualization needs (Simon, 2014).

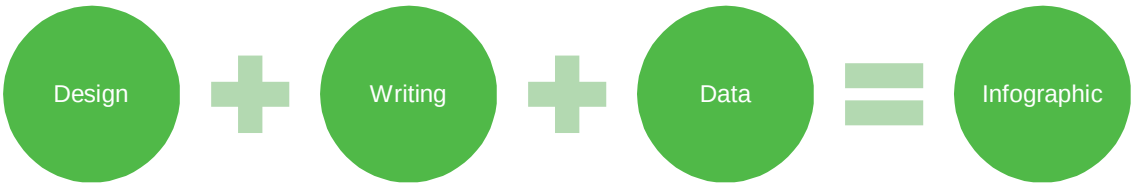
4.4.1. Excel charts and infographics

Excel and other spreadsheet tools are probably one of the most used tools in organizations worldwide. They have wide variety of charts and other SmartArt tools to visualize data; and thanks to macros and other features, excel charts can have some dynamic features, limited as they might be. Figure 12 shows a random selection of charts created with excel.

Figure 12. Variety of excel charts (Dashboard Insight, 2007)

Infographics are usually created to share information in a visual and easy to understand form. They are static presentations of a subject and normally they comprise of three issues that are design, writing and data. The amount of writing is kept minimal and data is generally presented in graphs and other visual forms. Infographics are this generation's posters that have become very popular because they are easy and fast to understand and easy to share through social media. Many companies use infographics to communicate their values inside and outside corporation walls and to promote their products. Figure 13 is a typical example of infographic with design and data in easy form.

Table 9. Building blocks of infographic (Adapted from Parlette-Stewart & Robinson, 2014)



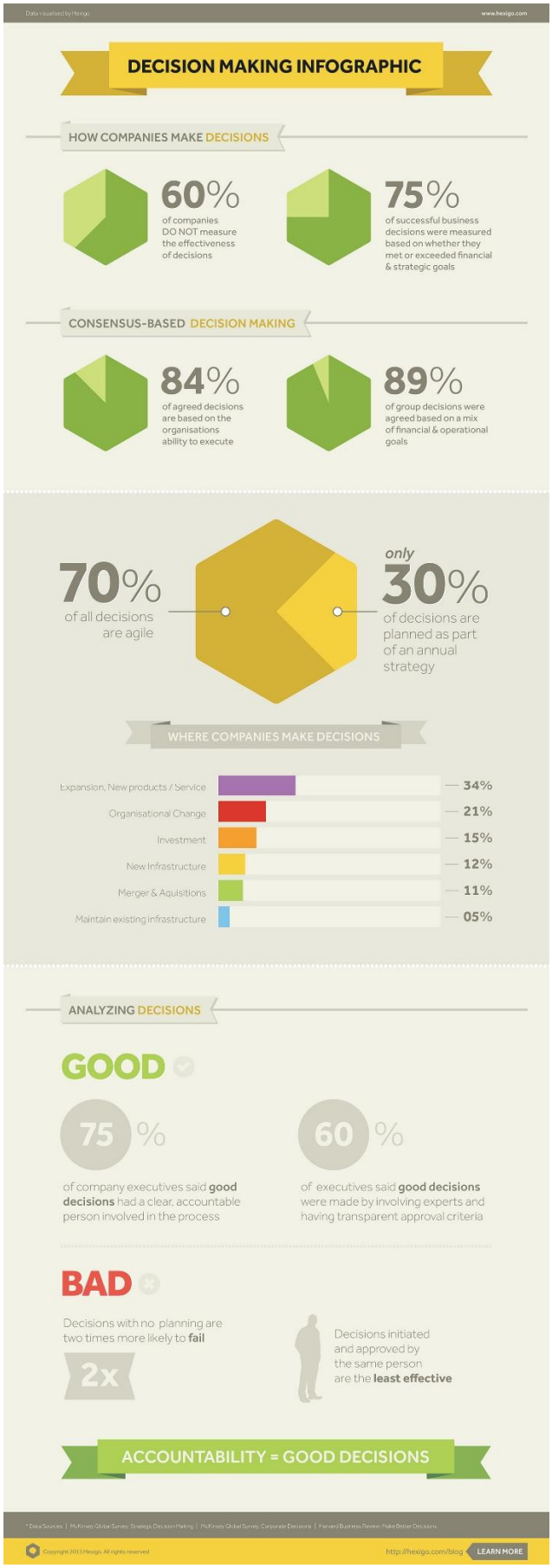


Figure 13. Infographic of decision-making. (Hexico Blog, 2013)

All types of static reporting and visualization must be presented consistently to enable comparison over time and so that the trends seen can be relied on (Stodder, 2013). Scorecards and other performance metrics are typically static information as well. They can be presented in a graphical form with gauges, widgets, dials, race cars or other visual clues to better communicate their purpose and engage people to improve results (Stodder, 2013).

4.4.2. Qlikview

Dynamic data visualization techniques are coming more and more popular when - through interactive workspaces like dashboards and portals - users are able to manipulate data behind the growing library of charts and other visualizations (Stodder, 2013). This enables users also to drill-down and truly explore the data and learn from it. This is also called visual data discovery. Dynamic data visualization tools are built to be easy-to-use and self-service products so that “nontechnical” users can effectively access, report and analyze data (Stodder, 2013). Currently many scorecards and reports that have been very static before can be created to be dynamic with visual data discovery tools. Operational alerting can be added to important key performance indicators and other figures to communicate the state of the figure. Often colors, for example traffic lights, are used in this context to indicate states of good, normal and bad (Stodder, 2013). When the functions of data discovery and operational alerting are combined the user can be able to spot the problems fast and even find the cause for them from the data set.

Many large international IT companies and small spin-offs have created their own product for dynamic data visualization (Zhang, et al. 2012). One of these products is Qlikview from Qlik (www.qlikview.com). Qlikview is a self-service business intelligence tool for combining data from different sources and showing it in a clear, visual way (Qlikview webpage, 2014). Figure 14 shows an example of Qlikview application’s interface. This application presents a helpdesk management dashboard with different kinds of visualization related to helpdesk cases.

There are also a lot of additional applications created on the top of basic Qlikview that enable even wider variety of visualization options. Qlik has also launched a new product that enables even greater interaction between the end user and data. With the new tool, end users can create charts and other visualizations themselves. With just Qlikview it is possible but not in the most interactive way.

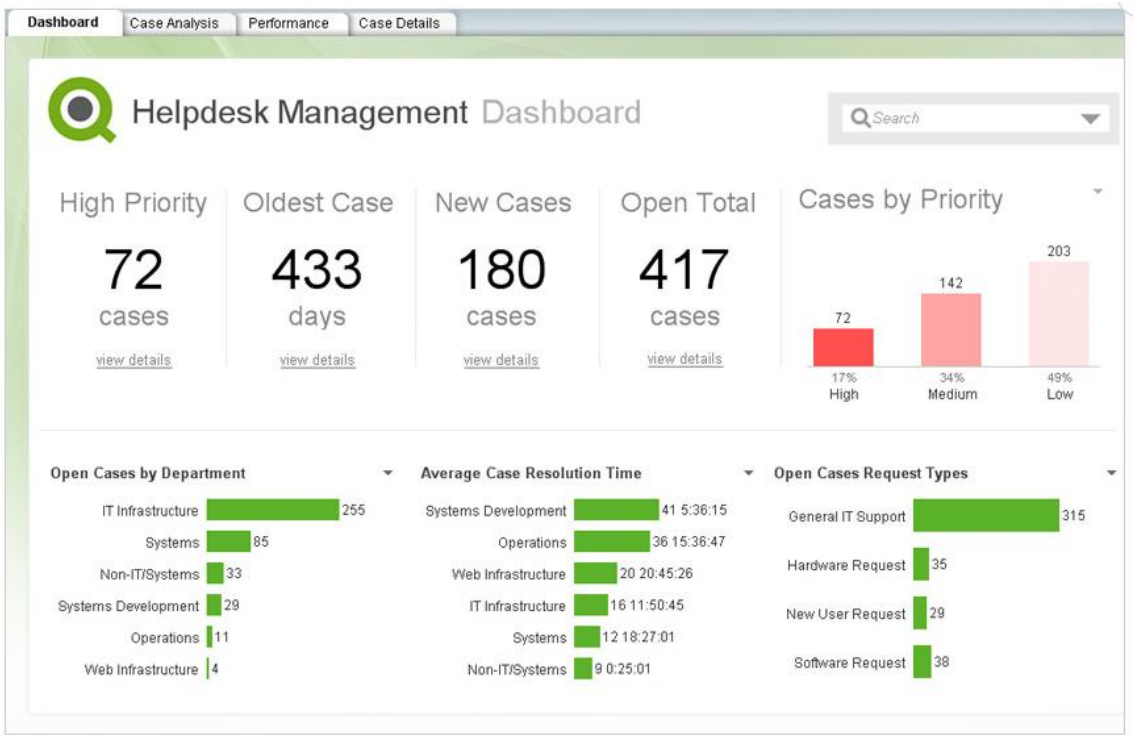
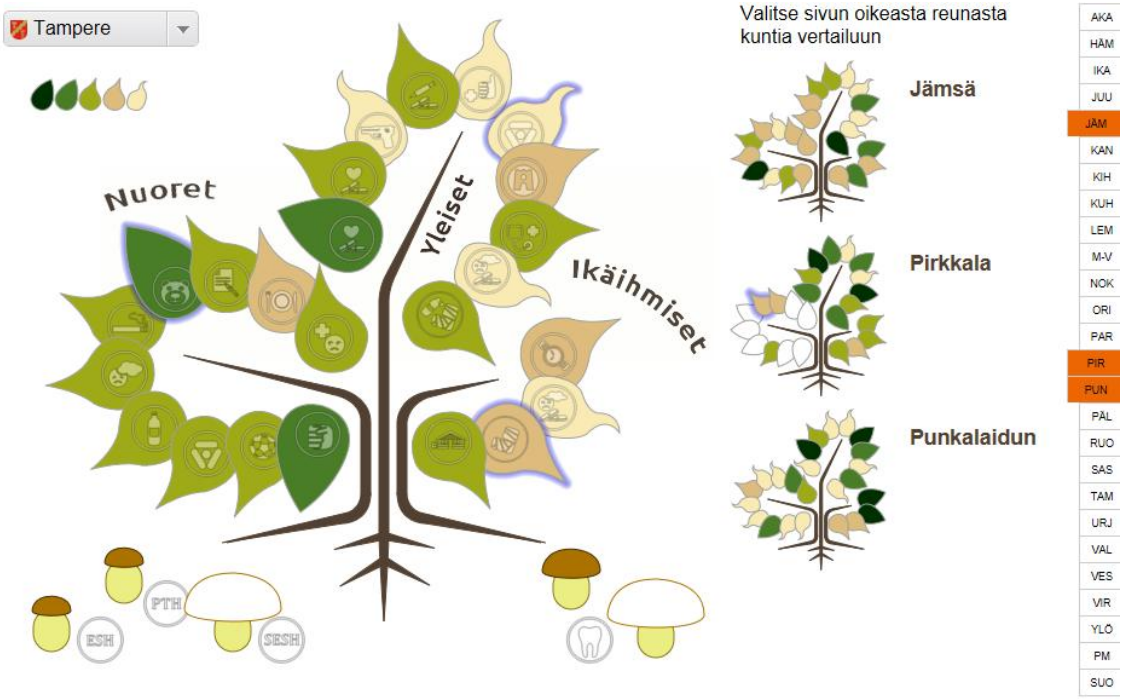


Figure 14. Example view of interface in Qlikview application (G2 Crowd, 2015).

4.4.3. Coded data visualization

The sky is the limit in data visualization techniques and tools. Coded data visualizations are currently the most developed visualization form. Coded data visualizations try to include as much data and information in the visualization as possible. This way they are even faster and easier to learn, use and interpret. They are usually online applications for internal or external use.

The more visually data can be presented, the easier and faster it is for our minds to interpret. Figure 15 shows an example visualization from a Finnish webpage www.terveyspuu.fi. This visualization shows how well people in Pirkanmaa municipalities are doing. One tree represents one municipality and by showing many municipalities at the same time, one can compare them. The tree has three branches that represent the young, the elderly and common issues. Each leaf is a key performance indicator (KPI) that you can click open and the numeric values open on the bottom of the page. The color and the shape of the leaf show the state of that KPI, the greener and stronger the better and the paler and withered the worse. White leafs mean no data. The roots of the tree show expenses of different healthcare segments and the mushrooms represent the amount of visits to different healthcare services. The larger the mushroom, the more visits there has been to that facility.



	Lastensuojelun avohuollollisten tukitoimien piirissä 0 - 17-vuotiaita vuoden aikana, % vastaavanikäisestä väestöstä	Vammojen ja myrkytysten vuoksi sairaalassa hoidetut 65 vuotta täyttäneet, % vastaavanikäisestä väestöstä	Työttömät, % työvoimasta
Tampere	9.2	3	12.7
Pirkkala	3.9	3.2	8
Punkalaidun	3	3.3	6.3
Jämsä	5.5	2.4	13.2

Figure 15 KPI visualization with one level drill-down option (www.terveyspuu.fi)

After getting familiar with the "rules" of the visualization, this kind of visualization makes it possible to process vast amount of data extremely fast and enable interpretations of the bigger picture. For example in figure 15 we can see that the young people of Tampere ("Nuoret" leaf in the largest three) are doing quite well compared to their counterparts in Punkalaidun.

Another visual data analysis example is different data tree that is used in the Finnish public sector quite a lot. It is for example used to visualize the revenues and expenditures of the nation (http://www.veropuu.fi/valtionbudjetti/). Figure 16 shows the estimation of the revenues and expenditures of Jyväskylä city in 2014. The gray area is the roots that show the streams of revenues, the thicker the root is, the larger the revenue. Same goes on the blue side that shows expenditures. The dotted line shows the profit.

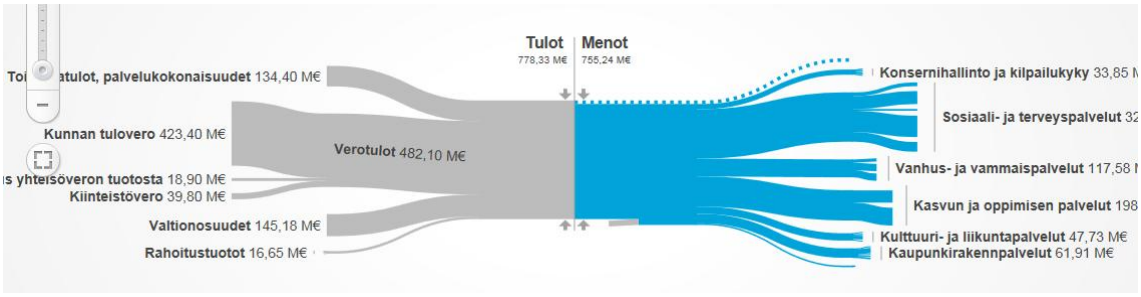


Figure 16. Tax tree that demonstrates incomes, expenditures and profit. Copyright Hahmota Oy

One can zoom in to see how the big roots branch to smaller roots like shown in the figure 17.

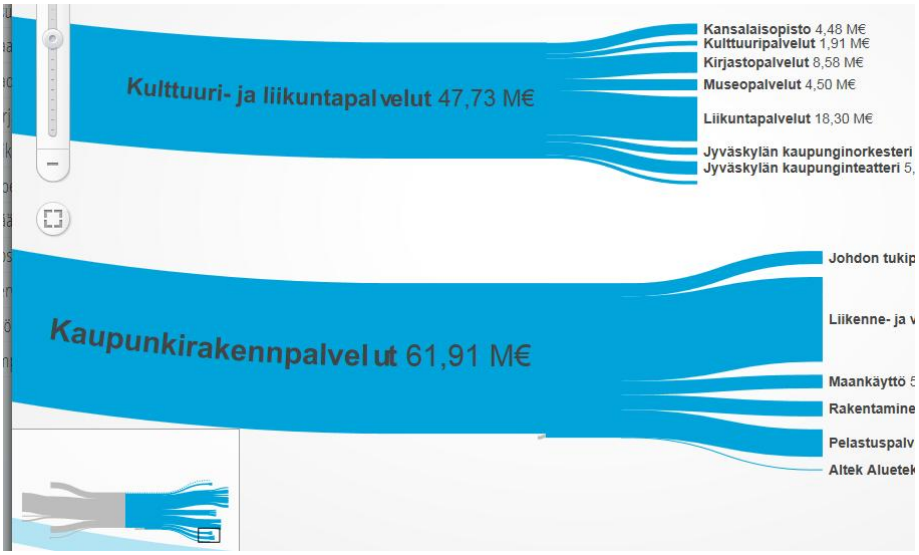


Figure 17. Drilling down in the tax tree. Copyright Hahmota Oy

Qlikview and many coded data visualization tools are created mainly to show and visualize numeric data. But sometimes the information is not in numeric form. One technique to visualize text information is a word/tag cloud. With a word or tag cloud the frequency of certain words or tags is visualized by showing the words that occur more frequently in a text, conversation, web page etc. The size of the words show their internal order in frequency and colors can be used to demonstrate groups or categories or the newness of the term. Figure 18 shows a word cloud created from this master's thesis.

Figure 18. Word cloud: (Picture of word cloud created of this thesis).Wordle.net

4.5. Data visualization in organizations

Data visualization is an action used in some extent by probably every company in the world. In TDWI research, around 80-90% of the studied 453 organizations were using or were planning to implement data visualization techniques to their daily work (Stodder, 2013). It is coming more and more important for organizations in the rising big data era because millions of rows of data need a proper framework to make it understandable (Simon, 2014). Without a proper framework, important insight may pass by unrecognized in the mass (Clark, 2014). The study shows that we are still in the early development phase in data visualization. Only one-third of the respondents said that they are currently implementing data visualization for discovery and analysis but 45% are planning to do so. (Stodder, 2013). In reality the number of current implementers might be higher because normal excel graphs and charts are not always considered as data visualization.

The same study, conducted by Stodder in TDWI Research (2013), shows that visualizations are developed and deployed by employees ranging from IT developers (in 62% of the respondent organizations) and business (54%) or data analysts (42%) to business executives (13%) and casual, nontechnical users (12%). In reality the amount of visualization deploying business executives is greater but they rarely participate themselves in the developing process (Stodder, 2013). 81% of respondents said that

visualizations are important for executives which show that executive managers highly value visualizations (Stodder, 2013).

According to Simon (2014) the short-term purpose of data visualization is to communicate information. Viegas and Wattenberg (cited in Simon, 2014) say that the long-term purpose and the primary purpose of data visualization is to enable better business decisions and even provide prediction (Simon, 2014). And today, the most valuable data visualizations are often based on the premise in which employees do not know exactly what they are looking for or what they are going to find (Simon, 2014). By exploring company data, employees are more likely to discover interesting revelations that might enable better decision-making and outcomes (Simon, 2014). Still executive managers value snapshot reports and scorecards the most from the data visualization techniques presented in the previous chapter. This might be due to the fact that snapshot reports and scorecards are more mature in organizations and therefore the appreciation for more developed visual data discovery techniques is yet to come. (Stodder, 2013).

According to John Sviokla (2009) data visualization has three main benefits:

1) **Efficiency**. Good visualizations let people look at vast amounts of data quickly.
2) **Better insight**. Especially related to the nature of the problem. Enables discovering of new understanding.
3) **Shared view**. A good visualization can help to create a shared view of a situation and guide people to beneficial actions.

Alesandrini (1992) adds memorability. The research results of Stodder (2013) support Sviokla's findings. In Stodder's research the respondents listed improved operational efficiency, faster response to business change and ability to identify new business opportunities as the top three business benefits of data visualization (Stodder, 2013).

TDWI research shows that functions in which data visualizations are most important are finance, sales and executive management. Again, the respondents valued snapshot and scorecards the most and visual data discovery and analysis second. Visual data discovery and analysis were also scored as very important for marketing and market research with two-thirds of respondents listing it as important. As it is, data visualization was considered important in some form in all nine functions at least by every third of the respondents. (Stodder, 2013). This shows how versatile and important tool data visualization is considered to be in organizations.

But data visualization as its own can create only little improvements in organizations. In order to truly benefit from visual data organizations have to adopt a new business model and become visual organizations (Simon, 2014). According to Simon (2014) visual organizations are ones that understand that in order to get the true benefits from data

visualization they have to incur the attendant costs caused by new tools, new hardware and new employee skills – and most importantly, new mind-set.

Some barriers lie in front of achieving these desired business benefits easily. Lack of skilled personnel or training, budget or resource shortages and difficulties in identifying or quantifying hard returns are some of these barriers (Stodder, 2013). Also problems in data quality can create barriers in visual data analysis (Stodder, 2013).

4.6. Characteristics of data visualization affecting decision-making

As was mentioned above, organizations cannot benefit from large quantities of data without proper frameworks and interfaces to present it in right manner. That is why decision-making is more and more backed-up with visualized data. This chapter gathers up large selection of characteristics of data visualization that have an effect on decision-making in different organizations. Figure 14 visualizes these characteristics by grouping them based on the three step decision-making process presented in chapter 3.1. Many characteristics affect decision-making in more than one step of the process but this grouping demonstrates how widely data visualization affects decision-making.

Section 4.2. stated that not all visualization are equal. It is known that some visualization create more insight than others. The problem is that humans do not always identify correctly what kind of visualization would give them the greatest amount of insight (Elting et al. 1999). In their study, participants saw information on a numeric table, pie chart, stacked bar chart and an icon display. Participants preferred numeric table the most but it produced low level of decision-making accuracy when compared to the icon display which produced the highest level of decision-making accuracy but it was the least preferred choice of these four. That is why when creating visualization; it is not advisable to trust solely on users subjective preferences. Instead visualization designers have to know and take the cognitive processes of users into consideration to maximize assistance for decision-making. (Elting et al. 1999).

4.6.1. Diagnosis step

Data visualization affects decision-making in diagnosis step in many ways. Good usability of the visualization tool lets the user focus on the task and not the system (Fekete et al. 2008). Clear and easy-to-use interfaces enable non-technical users interact with large variety of data sets. That is why interactive visualizations are more and more used as an interface between the combinations of human's visual system, flexible patter finder and adaptive decision-making mechanism and the computational power and vast information resources of the 21st century computers and the World Wide Web (Wide, 2004). Improving these interfaces can greatly improve the performance of the entire system (Wide, 2004).

Data visualizations have the ability to comprehend huge amounts of data (Ware, 2014). They are about developing insights from collected data, not about understanding a specific domain (Fekete et al. 2008). They reveal problems in the data, in the way it is collected and eventually in the process which makes them invaluable in quality control (Ware, 2014). They make the user ask questions that he did not know to ask and can answer to these questions (Fekete et al. 2008). Good visualization show known facts (that might be forgotten) and reveal several new ones (Fekete et al. 2008). Also, good visual representation has to match the task it is addressing (Fekete et al. 2008). That is why it is important to design the visualizations properly.

One of the most useful characteristic of data visualization is the drilldown option. With drilldown, organizations can create understanding of large-scale and small-scale features of the data especially by linking the perception of patterns into local features (Ware, 2014). They can also investigate perception of emergent properties that were not anticipated (Ware, 2014).

In diagnostic step, decision-maker looks into the available data and tries to create understanding of it. Data visualization can influence his high-level cognitive processes, like retrieval from long-memory (Elting et al. 1999), and by this generate insight that would not be formed without the data visualization. Data visualization can also help him to form hypothesis by enabling him to see the data from different perspectives (Ware, 2014).

4.6.2. Action selection step

Interactive data visualizations have a number of advantages to support decision-making by moving stress from system 2 to system 1 (Ware, 2014). Visuals augment human memory and therefore provide larger working set for thinking and analysis (Fekete et al. 2008) When stress is moved for system 1, system 2 can focus on the task in hand – decision-making. System 1 interprets the visualization and feeds the already processed information to system 2 so that the information can support system 2's thinking process without undue stress.

Data visualizations are meant to speed up the decision-making process by helping the perception system to work faster (Fekete et al. 2008). This will shorten the action selection step and leads to faster decisions. Also the increased availability of data speeds up the process. Data visualizations reduce search for information (Card et al. 1998) because in current situation users have to jump between reports, applications and databases to form the complete view (Stodder, 2013). Data visualizations also enhance users' self-directed business intelligence and data discovery (Stodder, 2014). This reduces decision-makers need for other people in the decision-making situation. It also brings up trends by showing patterns that can reveal structures (Fekete et al. 2008).

Modern, interactive data visualizations help users to collaborate with each other in the action selection phase with shared visualizations and they can learn from each other through those visualizations (Stodder, 2014). This way the selected actions are better understood by everyone because they have been based on facts that all the decision-makers can see in the visualizations. When visualizations unite data from different business lines, functions and areas, different users search for different facts from them. When these users collaborate with their findings and questions, new insight and knowledge is usually formed.

4.6.3. Implementation step

Visualizations also create benefits in communications and other collaboration. Modern visual data discovery scoreboards and charts can be published in other services like intranet sites and Microsoft SharePoint and they can be send through email and viewed with mobile devices. They can also be linked to another information like videos or audio files. Dynamic visualizations also generate questions and conversations. When data or information is visualized, people can interpret it in different ways. This usually generates fruitful dialogue that can be further investigated or answered with the dynamic characteristics of the visualization. (Stodder, 2014).

Improved performance can be achieved when data visualization leads to better decisions (Stodder, 2013). From the decision-making perspective, it is crucial to see the relevant data as quickly, easily and fast as possible (Morales-Chaparro, et al., 2011). The further the data is constructed, the more visual it is, the faster and better it is interpreted by the viewer (Simon, 2014). They are critical in providing actionable insight for decision-makers because they enable the decision-makers to focus on the situation at hand instead of focusing on the creation of charts and uniting the right data from right sources (Stodder, 2013).

When a decision is being implemented in the organization, its progress and results are usually followed. Data visualization can be used to visualize the measured results and this way improve performance metrics and measures (Stodder, 2014).

The level of transparency required from companies is increasing. We are far from the times when publishing basic financial information was enough. Wide pool of stakeholders (shareholders, customers, authorities, employees and society in general – to name a few) all require their own information regarding company's behavior, operations and performance (Tapscott & Ticoll, 2003). Also internal transparency plays an important role especially in large corporations where functions are geographically distanced and employee turnover is faster and larger. With greater transparency companies can improve quality of the enterprise data, avoid unnecessary risk taking and enable organizational sharing and collaboration (Simon, 2014).

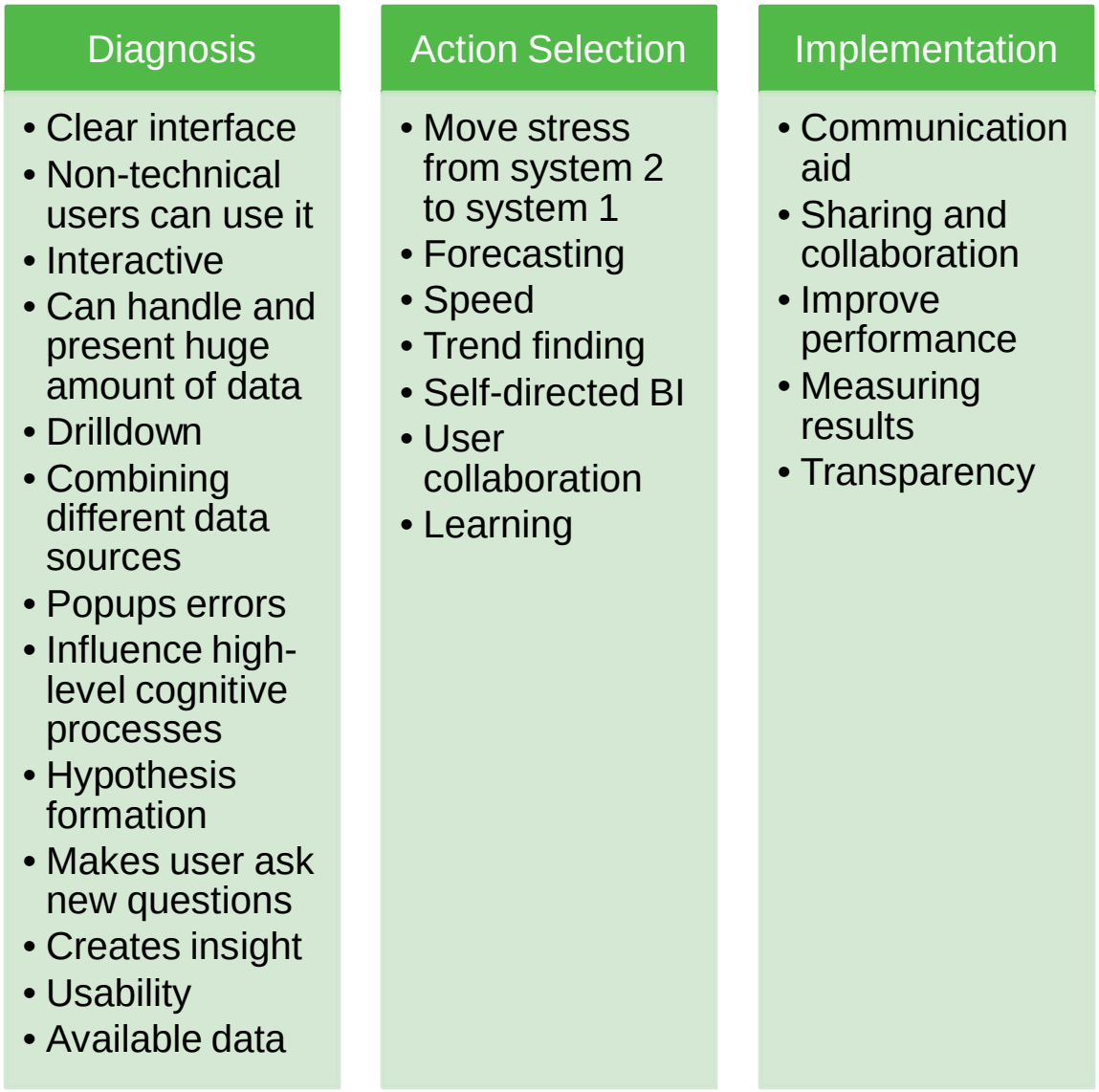


Figure 19. Characteristics of data visualization affecting decision-making process

Data visualization can affect decision-making both in a good and bad way. Visualizations usually underline deviations in the data. If the data under the visualization is incorrect the visualizations highlight false information given by the false data. This way the decision-maker can be led wrong and he can do wrong decisions or lose confidence in their visual business intelligence function. (Stodder, 2013).

The ultimate value of data visualization is based on the increase of knowledge and the costs made to obtain the insight (Fekete et al. 2008). Obviously, it is difficult to concretize how much knowledge increases and thus determining data visualization value is not easy. That is why, in this thesis, the value of data visualization is measured only in qualitative manner through interviews.

4.7. Data visualization development process

In general data visualization process can be very straight forward and iterative. It starts with the predesign phase in which the current situation is observed and analyzed and discussed with expert users (Basole, 2014). Main things to observe are the users, tasks and decision management (Basole, 2014). But according to Patterson et al. (2014) the role of user's cognition is often left unspecified and the focus is mainly on the data.

Data visualization is usually created by certain employees in the organization or consultants because many users are not familiar with potential visualization alternatives and opportunities (Basole, 2014). Also data visualization generally requires knowledge of programming, data mining and tools that are used for data visualization. To start the designing phase, the visualization ideas and users' needs are communicated through paper sketches and the necessary data bases and data sets are recovered and a sample set of data is obtained (Basole, 2014).

After this the data is organized and curated and potential (interactive) visualizations are created to present to the expert users and other stakeholders (Basole, 2014). According to Basole (2014) usually in this phase the users begin to see the value of interactive visualizations tools and are able to request visualizations that are more useful to them (Basole, 2014). Visualization designer has to combine his knowledge about human visual processing into these requests because like was mentioned earlier, the user does not always know what visualization creates best results. When designing visualizations it is also important to take into account human sensory capabilities so that important data elements and data patterns can be quickly perceived. Important data should be presented in visually distinct way to make it pop out from the less important information. This way it is easy to find. Also numerical quantities should be made larger, more vividly colored, more strongly textured or other ways distinguishable. (Ware, 2013).

In the last implementation phase, the tool is implemented to the work context (Basole, 2014). Each phase can include multiple iterations and these iterations usually include analysis, design and evaluation activities such as observation, interview, cognitive walk-through and usability testing (Basole, 2014). The process is clarified in the figure 20.

Figure 206. Data visualization process. Each process phase can include multiple iterations with analysis, design and evaluation activities (Adapted from Basole (2014)).

Currently, only a few visualization designs include perceptual and cognitive methods to their development process. Methodology for designing visualizations is still quite ad hoc and informal. (Patterson et al. 2014). When perceptual and cognitive methods in data visualization will be more studied their usage in visualization development will hopefully increase.

4.8. Future of visual business intelligence tools

Fekete et al. (2008) predict bright future for the field of visualization. They base their prediction on assumptions of large number of potential users, ubiquitous amount of data in a forms of tables, hierarchies and networks and increasing need to get insight of data (Fekete et al. 2008). Gartner's view of business intelligence's and analytics' future shows similar assumptions. Gartner predicts that the market for business intelligence and analytics platforms (such as Qlikview) will remain one of the fastest-growing software markets. (Gartner, 2015). Business users' growing need to self-service data discovery foretells also growth in the need of easy to interpret, visual interpretations of data. The use of visualization is increasing in organizations as well as in homes which is shown by the increasing number of casual visualization tools and creations (Fekete et al. 2008; Gartner, 2015). Also the TDWI research shows that 45% of organizations are planning to implement data visualization technologies (Stodder, 2013).

Next step in data visualization will be higher level of interaction and more power to the business users (Gartner, 2015). This can mean for example that users do their visualization mainly by themselves. As was mentioned with Qlikview and Qlik's new tool, Qlik Sense, which is built to enable user created visualizations of data. Still not all agree on this prediction. Fekete et al. (2008) believe that the average user will not be interested in creating his own visualizations but his interest will be entirely on solving his own problem by using visualizations as one mean.

To understand large and unpredictable datasets, interactive data visualizations are usually superior to static standard reports, dashboards and infographics (Simon, 2014). Static presentations limit what users can do with them. They disable interaction with the data for example by preventing exploration with drill downs and arounds. Because of this, it is hard to find answers to newly emerged questions from the data (Simon, 2014). Gartner sees interactivity as one of the key aspects of visual business intelligence tools in the future. By 2017 most data discovery tools will have incorporated smart data discovery capabilities to expand the reach of interactive analysis. (Gartner, 2015).

Fekete et al. (2008) highlight the importance of integration when it comes to visualizations. This is one important issue when talking about the future of data visualization. Users prefer when visualizations are embedded and integrated to their favorite tools and communication platforms such as webpages and newspapers (Fekete et al. 2008). In future interactive visualizations have to be implemented to environments

that support their functions and the collaborative way of living and working. They can be shared through company internal webpages for example.

Business user driven, self-serving, interactive and integrated visual BI tools will be the most wanted BI tools in future (Gartner, 2015). Larger interactivity and interaction enables users to ask more complex questions and therefore lead to better insight. Integration will also unite working tools and methods and therefore make working and decision-making easier. Governing this type of open, self-served BI will be one of the big challenges in the future (Gartner, 2015).

Other issues affecting visual BI tools will be the move to cloud and business users' demand to access self-service capabilities beyond data discovery and interactive visualization of IT-curated data sources – they want access to the data preparation tools that are sophisticated and business-user accessible (Gartner, 2015). Another major target is to close the gap between business intelligence and decision-making. New collaborative and social visual BI offers the potential to do that by facilitating intelligent collaboration, sharing and capture of the interactive decision process that enables more transparent and high-quality decisions (Gartner, 2015). Through all these actions BI in general is slowly being embedded into applications and business processes so that it will deliver optimized insight on a point of decision or action anytime, anywhere (Gartner, 2015).

5. RESEARCH DESIGN

The main frame of this research is presented in the research onion (Figure 21) that is adapted from Saunders et al (2009). The onion describes the chosen structure of the research starting from the outlines of limiting factors and the material available, working its way inwards through philosophy, approach, strategy and eventually used methods. The layering of the onion describes how the terms are related to each other. All the layers are further presented in the sub sections of this chapter and the relation to this research will be explained likewise.

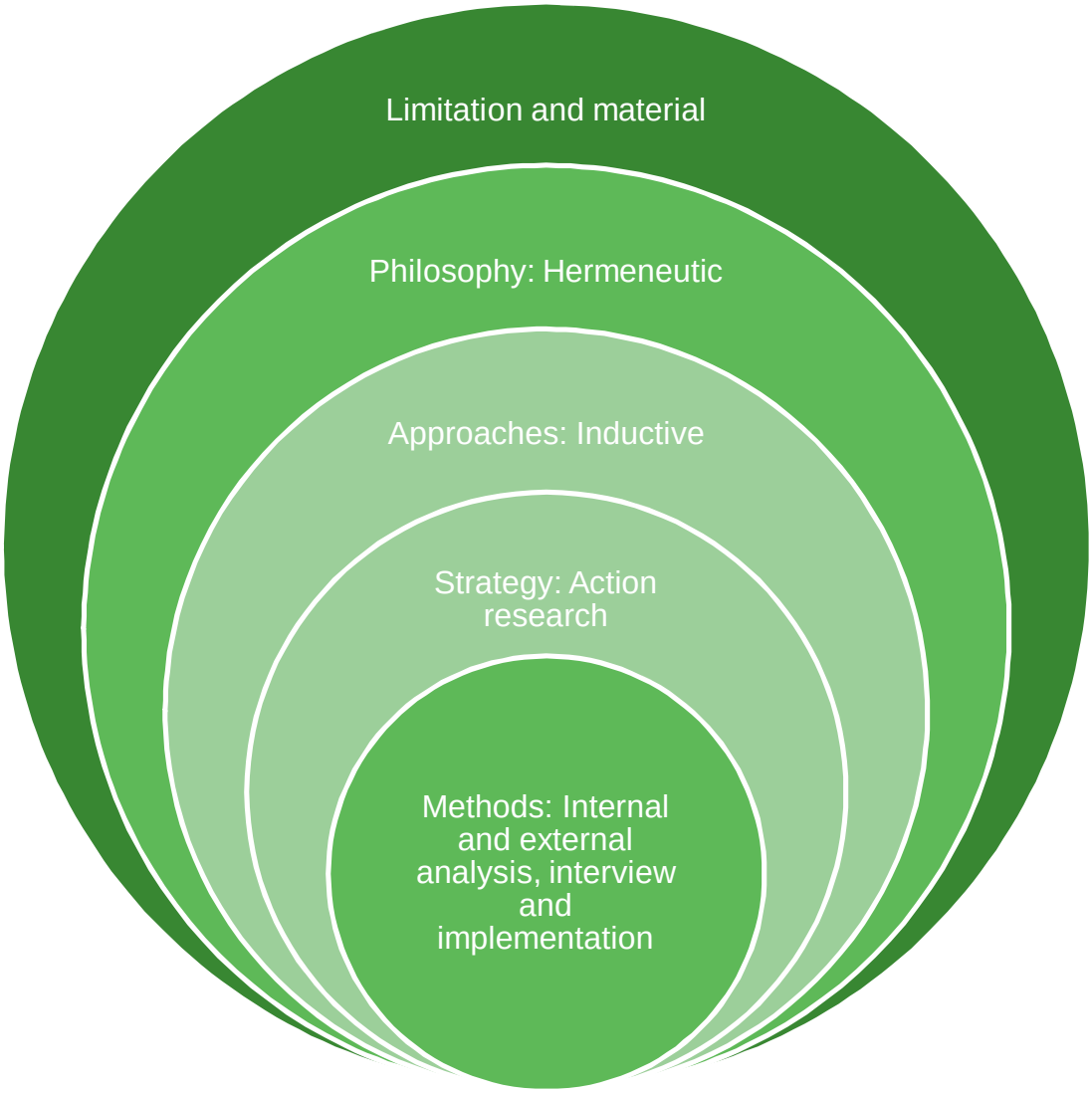


Figure 21. The research onion. Adapted from Saunders et al. 2009

5.1. Limitation and material

The focus of this research is guided by the current needs of the target organization. Therefore the entire demand-supply chain will only be very briefly examined and the further focus is concentrated to a smaller part of the chain, to sales-delivery processes. The thesis is done under one of case corporation's three business lines which can create certain limitations but the outcomes of the thesis hopefully will serve the company in whole. The target time frame for this research has been six months so we can say that the time is one limiting factor. Because of this - the research is cross-sectional meaning that the situation is observed for a limited amount of time and not over many periods (Gray, 2013).

The research material consists of:

- Large variety of research papers related to transparency, decision-making, data visualization and demand-supply chain
- Information gathered from the internal releases and tools of the case corporation
- Researcher's own observations and notions formed while working in the target organization
- Interviews and conversations conducted with different employees of the company

5.2. Research philosophy and approaches

This master's thesis is based on qualitative research and the philosophical approach to the subject is hermeneutical. Hermeneutic research aims to systematically form meaningful interpretations of the research subject (Väkevä, 1999; Smythe & Spence, 2012). As the object of this thesis is to clarify processes in the demand-supply chain and increase their transparency - hermeneutical research is appropriate philosophical frame.

It is important to keep in mind that interpretations are always influenced by the background of the researcher and other stakeholders of the project which can bring valuable insight to the execution and the end result of the research (Smythe & Spence, 2012). But it can also harm the purity of the research (Patton, 1999). Especially in qualitative research interpretations play an important role because results are not mathematically proven but proven by explanations that are always interpretations. In hermeneutics the research object is usually variety of social settings (i.e. people and processes) (Olkkonen, 1994). These are also some of the objects of this research.

To be able to start forming interpretations of the research object – a suitable approach needs to be found. In general, there is two different ways to approach a research and a research problem - inductive and deductive (Gray, 2013). Inductive approach means that the research moves from an accumulation of data to a hypothesis which is then

tested in the target organization (Gray, 2013). Deductive approach starts from the hypothesis and moves towards the proved fact by testing, modifying and confirming the hypothesis (Gray, 2013).

Because the research subject and the target organization is quite unfamiliar to the researcher the approach to the subject is more inductive than deductive. This way the research can be started by first investigating current information in the internal and external sources and from there move towards the actual problem in hand. But for a research to be completely inductive there should not exists any pre-defined hypothesis or expectations (Gray, 2013). In a research project like this, there exists some ideas and expectations related to the outcomes of this thesis that are set by the target organization. And also as was mentioned before, researcher's own background always influences in some amount how the data is interpreted but the goal is to process the collected information as widely as possible to prevent any hasty inferences or conclusions (Gray, 2013).

5.3. Research strategy and structure of the research

The research strategy in this thesis is action research. In action research, the goal is to as well examine as change current practices (Baskerville & Myers, 2004; Saaranen-Kauppinen & Puusniekka, 2006; Cohen et al. 2007). With the combination of action and research the researcher attempts to understand, improve and reform practices (Hopkins, 1985). According to Van Eynde and Bledsoe (1990) it is the primary methodology for the practice of organizational development. It was primarily designed for social studies but currently is used in many other fields as well (Baskerville & Myers, 2004). Action research attempts to solve real problems by engaging people from the target organization to the research (Saaranen-Kauppinen & Puusniekka, 2006). By collaborating general theories and situated and practical knowledge of interviewees it is possible to make changes that benefit the target organization as well as create new knowledge about the studied area (Baskerville & Myers, 2004).

The founder of action research, Kurt Lewin, proved in a very systematic study how by involving people in the research process and the change planning the outcomes are much more promising. Job satisfaction, work morale and productivity are more likely to stay on the same level or increase when workers can influence the changes that are planned in their organization (Saaranen-Kauppinen & Puusniekka, 2006). Action research seeks to change the current practices in real-time by enhancing or improving them even in a small way (Saaranen-Kauppinen & Puusniekka, 2006). This is also a request from the target organization, making small improvements along the thesis project and not just in the end of it or after the research is conducted.

Because action research is quite straightforward, it might sound like the normal development task that is conducted every day in various companies. But it is not.

Kemmis & McTaggart (1992) say that action research is more systematic and collaborative in collecting evidence than normal problem solving. It also includes problem-posing and is motivated by a larger quest to understand the world by changing it and learn from the changes. Also, it is not a research done to other people but instead to particular people on their own work or environment with the help of others involved. (Kemmis & McTaggart, 1992).

Action research builds on simple two-stage process. In the first stage, the situation is analyzed by the researcher and employees involved in the thesis project. Also the hypothesis are developed. This stage is called the diagnostic stage. The therapeutic stage is the second stage in which the collaborative change is conducted. (Baskerville & Myers, 2004). In the second stage the changes are introduced and the effects are studied (Blum, 1055). The process can be further more divide into six phases that are (Baskerville & Myers, 2004; McKernan, 1991):

(1) Analysis (2) Fact finding (3) Conceptualization (4) Planning	Diagnostic stage
(5) Implementation of action (6) Evaluation	Therapeutic stage

Different methods are used in different stages of the action research. In this master's thesis, the order of the six phases are not faithfully followed but suited to fit the needs of this research. The first phases of diagnostic stage, analysis and fact finding, are conducted by firstly examining the scientific research related to the scope of this thesis. This material is then reflected to the current situation in the case company. Figure 20 shows the structure of the empirical research. The first action box – internal and external analysis, represents the analysis and fact findings phases of the research. Input for these phases are the research problem and questions. The analysis methods and other used methods are more thoroughly presented in the next chapter 5.3.1. Research Methods.

The third phase, conceptualization, is done using the outputs of the internal and external analysis to form concepts of the discovered problems and opportunities. These concepts work as input for the interviews which represent the planning phase of action research. In these interviews the researcher and case company representatives together plan solutions for the concepts. The last action box in figure 22, represents the therapeutic stage of action research. The planned solutions are implemented and tested and evaluated by the case company representatives. Because Ebbutt (1985) emphasizes the importance of feedback within and between each phase, feedback will be collected from all the collaborated members during the research process and also after their contribution.

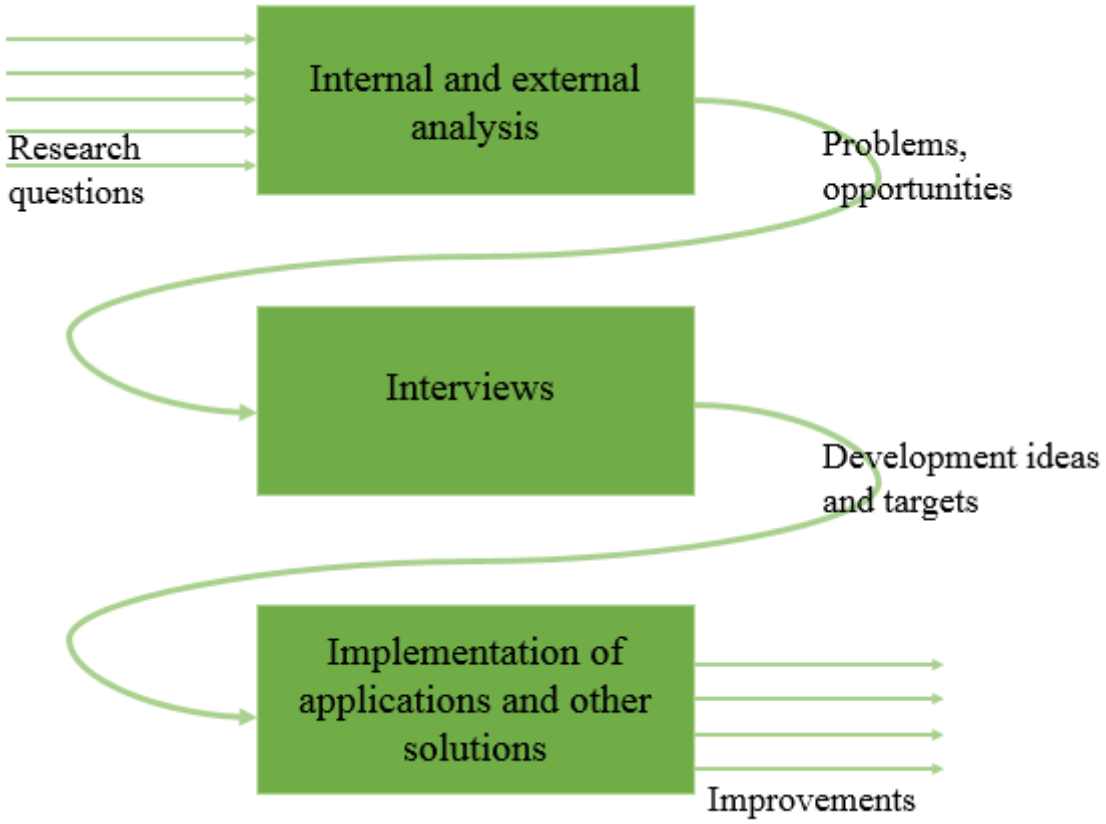


Figure 22. Empirical research strategy

The next sub section introduces more thoroughly the methods that have been used in the different stages. The methods are represented in the extent that is relevant for this thesis and therefore may not give full image of the method.

5.3.1. Research methods

The research is done by exploiting different research methods for different purposes during the research process. Two analyses are made, one to organization's external sources and one to internal sources to provide context for this thesis. Interviews are used to get better picture of the problem in hand. In therapeutic stage of the research - implementation is used to agility develop applications and solutions to encountered problems.

External and internal analysis are mainly used in the first stage of the research. External analysis is an analysis of external literature sources. In hermeneutic research literature analysis is usually used for providing context and provoking thinking (Smythe & Spence, 2012). Literature can include anything that inspires to think the phenomenon in hand and to emerge new insight (Symthe & Spence, 2012). Summary and highlights of this external analysis are presented in the previous chapters two, three, four and five. The used external material consist mainly of scientific publications and books and they were found using four different search tools. These tools were www.scholar.google.fi, www.nelliportaali.fi, www.scienceresearch.com and www.twitter.com. Articles were

searched using keywords: business intelligence, data visualization, visual business intelligence tools, visual analytics, demand-supply chain, transparency, decision-making and their synonyms. Most of the source material is published within the last fifteen years so it is up to date in most parts. Therefore, the study contains a review of the state of demand-supply chain transparency and usage of data visualization in 21st century but might lack some very recent development in these fields.

Internal analysis includes investigation of the company's internal sources such as intranet, databases and internal publications. Internal analysis also includes discussions with multiple employees from different functions of the organization. The purpose of internal analysis is to get insight to the current state, processes and culture in the target organization. Main target was to find out what are the problems visual business intelligence tools could solve and how it would improve transparency and decision-making.

Another used method was interviews. Interviews enable participants (interviewer and interviewees) to discuss their interpretations of the discussed matter from their own point of view (Cohen & Morrison, 2007). It is a flexible tool to collect data from multi-sensory channels – verbal, non-verbal, spoken and heard (Cohen & Morrison, 2007). The interviews were very informal and semi-structured. Most of the interviewees were interviewed multiple times while the research project moved ahead.

Implementation research aims to promote options and best practices on how to use resources to better uptake research findings. It is usually done by testing approaches to change organizational behavior. (van der Weijden, 2011). In this thesis it is used to tentatively implement created solutions so the project could go on even after the thesis work is completed.

Table 10 summarizes the main characteristics of each research method. Presented is the purpose of each method and the research stage in which it is used and the chapter in which it is presented. Methods that are used multiple times for multiple reasons (interviews) are presented separately. Table 10 also lists participants for each research method and the outcomes. Diagnostic stage is conducted using external and internal analysis to provide context and insight of current situation in the organization. These methods are used solely by the researcher. Discussions cannot be listed as interviews because of their very informal structure but they play a minor role in the insight creation process. Interviews 1, 2 and 3 (Table 10) are scheduled for the diagnostic stage to create better understanding of delivery operations in the target organization and about the understanding and current state of transparency. Therapeutic stage consists of interviews 4 and 5 and of implementation of created solutions.

Table 10. Summary of research methods

Research Method	Purpose	When	Participants	Outcome
External analysis: Scientific publications	Context providing	Chapters 2-4	Researcher	Theory, context for the study
Internal analysis: Internal publications	Insight of the organizations current state	Diagnostic stage, analysis: Chapter 6.1	Researcher	Knowledge of current situation, sales and delivery process
Internal analysis: Discussions	Insight of the organizations current state	Whole diagnostic stage	Researcher and 5-10 company employee from different functions	Knowledge of current situation, sales process
Interview 1	Demand side of demand-supply chain	Diagnostic stage, analysis: Chapter 6.1.2	Researcher and Manager, sales	Sales process and desires for data visualizations
Interview 2	Supply side of demand-supply chain	Diagnostic stage, analysis: Chapter 6.1.3	Researcher and Director, engineering	Delivery process
Interviews 3	Find out what is the current level of transparency in Valmet and what are the problems and development needs regarding it.	Diagnostic stage, fact-finding: Chapter 6.2.	Researcher and 1.Vice president, Operational Excellence; 2.Manager, Project Operations; 3 & 4. Senior Manager and Manager, Sales & Technology	Current level of transparency, improvement ideas, development subjects for therapeutic stage
Interviews 4	Discussions during development work for visualization tool	Therapeutic stage, implementation of action: Chapter 7.1	Researcher and Senior Manager and Manager, Sales & Technology	Requirements and feedback for demand-supply chain visualization tool
Interviews 5	Discussions during development work for visualization and simulation tool	Therapeutic stage, implementation of action: Chapter 7.1	Researcher and VP, Operational Excellence and Business Analyst, Operational Excellence	Requirements and feedback for demand-supply chain visualization tool and demand-supply chain simulation tool
Implement-ation	Implement developed solutions	Therapeutic stage, evaluation: Chapter 7.2	Researcher and Senior Manager and Manager, Sales & Technology	Implementation of built solutions to one department

6. DIAGNOSTIC STAGE: Transparency in demand-supply chain

In diagnostic stage, the existing situation of transparency in demand-supply chain is analyzed and hypothesis on what could be improved are created based on the first four phases of the action research that are analysis, fact-finding, conceptualization and planning. Section 6.1. analyzes corporation's current demand-supply chain and data visualization. Section 6.2. shows the outcomes of the fact-finding phase which included interviews with company representatives related to transparency in the case company. Lastly in section 6.3. is conceptualized what could be done to improve transparency and decision-making and also planned what will be done.

6.1. Analysis of demand-supply chain and data visualization in the case corporation

The analysis phase included an internal analysis during which company publications and data were examined. Also interviews 1 and 2 were held to get better insight on the demand-supply chain functions in the case corporation. Interview structures are presented in appendix 1.

6.1.1. Description of demand-supply chain in the case corporation

Demand-supply chain in the target organization is very large and global. It has around 10 000 active suppliers in over 50 countries and customers in over 70 countries (Valmet, 2014). Case corporation's own production and other functions are divided into 30 production units and 70 service centers around the world. At the moment over half of the purchases from suppliers are done from Finland or Sweden when measured in supplier spend. (Valmet, 2014). The demand-supply chain includes multiple functions presented in figure 23.

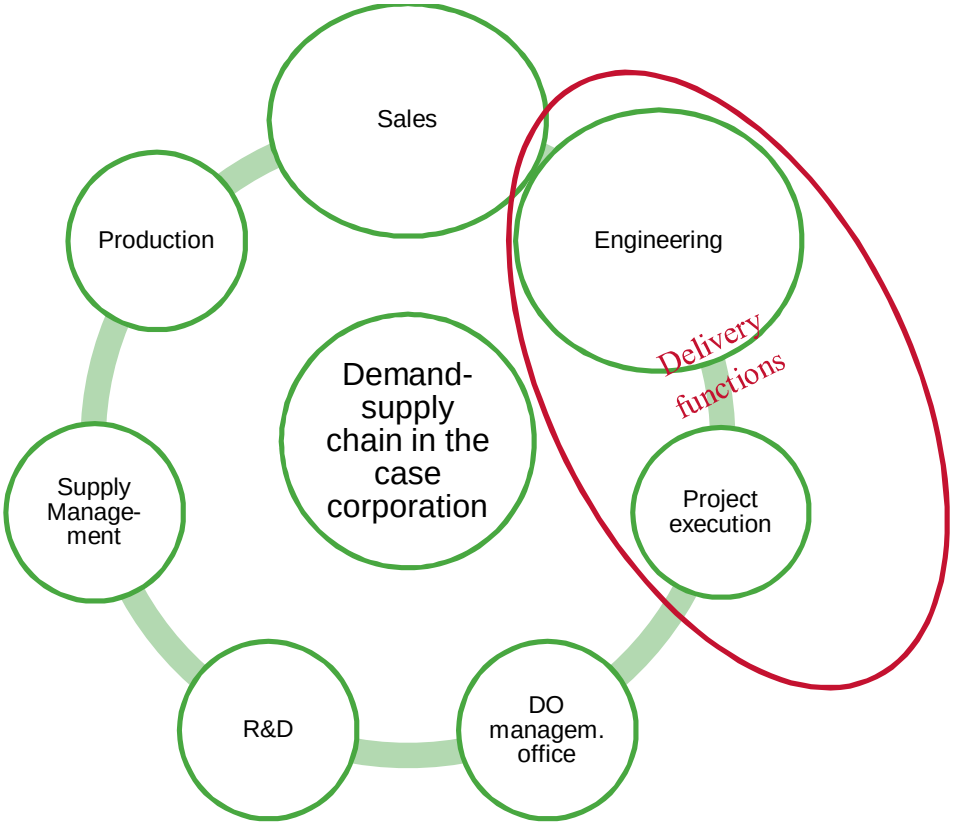


Figure 23. Demand-supply chain functions in the case corporation.

By comparing case corporation's internal publications to Lyons et al. (2012) definitions of different topologies it seems that their demand-supply chain topology is mostly hierarchical but it has some small characteristics of networked demand-supply chain as well. Figure 19 showed an example of this topology.

As was mentioned earlier, this research is limited to only include sales and delivery processes. And because the delivery function is rather large, we will examine more closely only engineering and project execution parts of it. With this limitation the research can be conducted more thoroughly and the number of participating employees can be kept in a proper size. But still it is kept in mind that the goal is to find solutions that can serve as wide range of functions across the business and process lines as possible. Next two sections explain how the core of the demand-supply chain, that being the sales, engineering and project execution, is constructed in the target organization by first introducing the sales process and then linking the other two functions to the sales.

6.1.2. Case corporation sales process

Corporation's business line sales process consists of six steps. It is in line with the typical customer buying process. This way it is possible to offer customers the information they require on the right phase of their buying process. The typical customer buying process shown in the figure 24 also includes six different steps that

start from the recognition of demand and goes through the phases of solution recognition, solution development and selection, vendor evaluation and finally assurance for selected vendor or solution.

Figure 24. Customer's buying process

Figure 25 demonstrates the case corporation sales process. The process starts with opportunity identification in which the sales representatives identify possible sales projects within corporation's current customers and other possible customers. In the next step "Opportunity validation"; the opportunity is validated and a rough scale bid is produced.

Figure 25. Corporation sales process

In indicative proposal phase, it is decided if the company is going to bid on the project or not. Next two steps are reserved for fine tuning the offer.

The last proposal phase "Firm proposal" usually takes the longest time and people from different parts of the organization are participating in the planning. In final negotiations usually only few companies are left in the tender. Final negotiations end to win or lose. And this leads the sale project to its closure.

Because case corporation's business, dealt in this study, is capital business, and the projects can be large in monetary and timely sense, a lot of emphasis is put on the opportunity identification and validation steps. The ultimate goal of any sales process is to reduce sales costs and resources put into the sales process and improve the win-rate by putting more effort on the finding and selection of the right projects in early stage.

All data from sales process is saved to CRM tool. Qlikview is used to form reports from the CRM tool and to visualize different financial and timely figures of the sales projects. Figure 26 shows an example visualization of sales data in Qlikview. It shows a sales pipeline with opportunities ratio per salesperson.

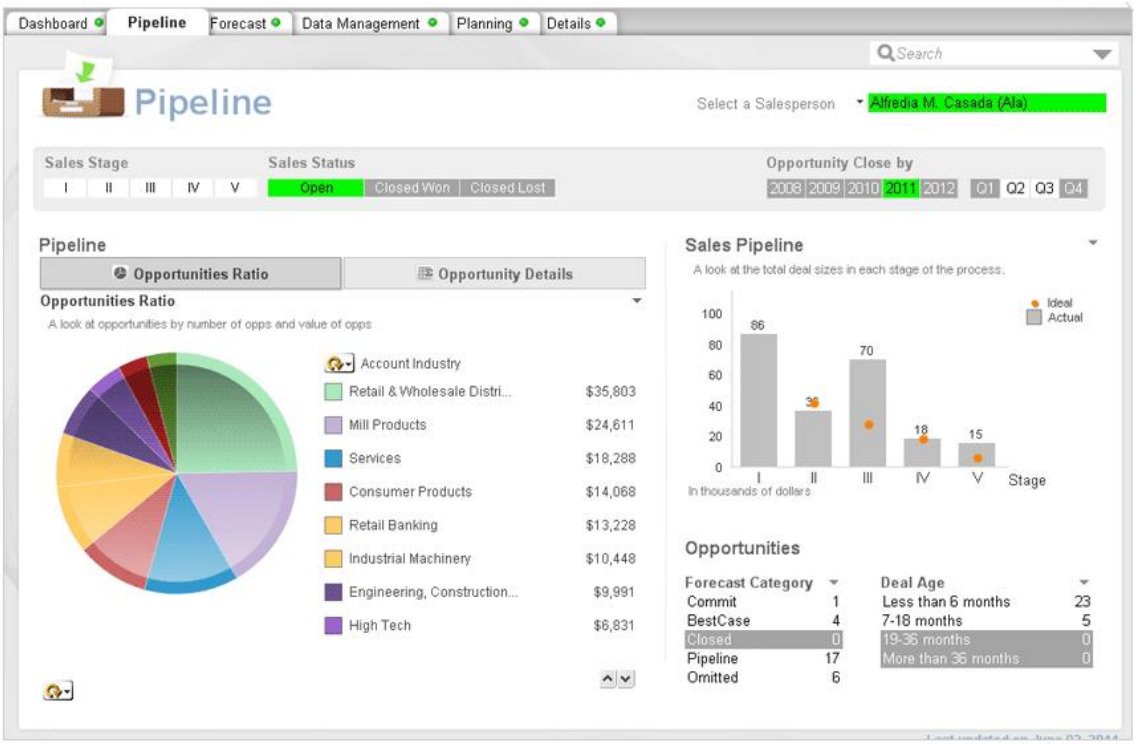


Figure 26. Example visualization of sales data in Qlikview (G2 Crowd, 2015)

6.1.3. Case corporation delivery process

According to Engineering director of the corporation, the role of delivery process is to make sure that the designing, manufacturing, installations, usability and other related parts of the delivered projects are executed in the best possible way. Supply of delivery resources (for example workforce) is based on the yearly budget. Actual demand depends on the projects received. Demand-supply planning is the action inside delivery process that makes sure that the supply and demand of resources is in balance. Basic framework of demand-supply planning is presented in section 7.2.

Because products and services, delivered by the target organization, can be very large and varied, the delivery is divided into different functions like engineering, project execution, supply management and production. These functions are then divided into even smaller modules like piping, E&I, layout and so on. The delivery processes are also divided into sales and project execution phases. Delivery process supports sales process by providing information about available and required resources in projects. Based on this information, sales can create their quotation.

Delivery process is based on project execution model (PEM). Figure 27 shows an example of possible delivery process with five project phases and multiple gates presented in orange background.

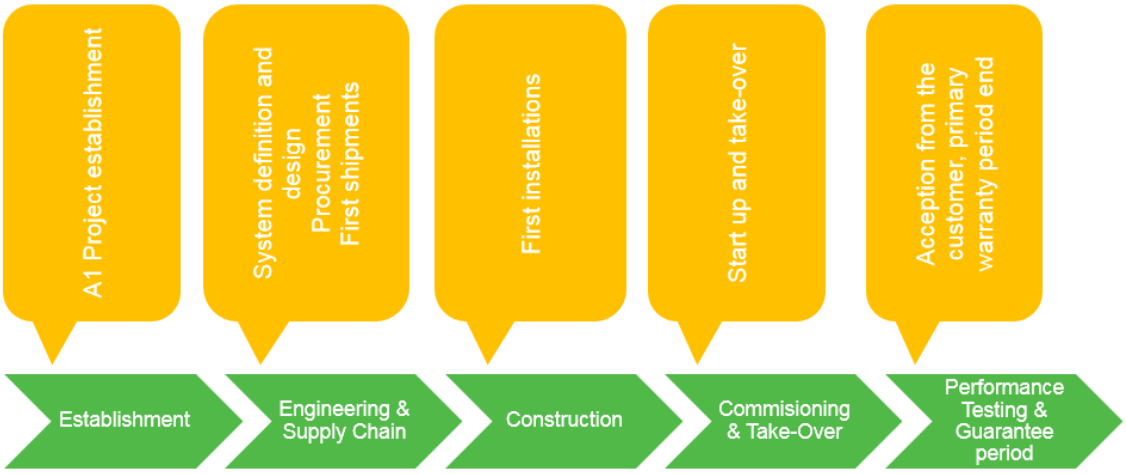


Figure 27. Project delivery process

Engineering's role is to plan and develop all engineering work related to the sales and delivery projects. Project execution makes sure that the overall project is executed in the best possible way. They take care of the schedule and financial monitoring and guidance.

6.1.4. Demand-supply planning in the corporation

In order to have a transparent demand-supply chain the communication about current and future projects between demand and supply functions have to work efficiently. Demand-supply planning is implemented in the corporation's operations to distribute and allocate resources for on-going delivery and sales projects and to create estimations for the future.

Demand-supply planning is based on the sales and delivery projects that are in the company budget plan. Available resources (for example engineering hours) are determined in special resource meetings. Delivery operations representatives attend the sales meetings to know what the current situation is with the on-going sales projects. Based on this information, their teams evaluate and calculate the estimated resource requirements for each project and each resource. Used resources is followed in a special "Workload"- Qlikview application. Figure 28. shows an example how workload can be visualized in Qlikview application. It shows an energy maintenance dashboard with open orders as a bar chart and in a map.

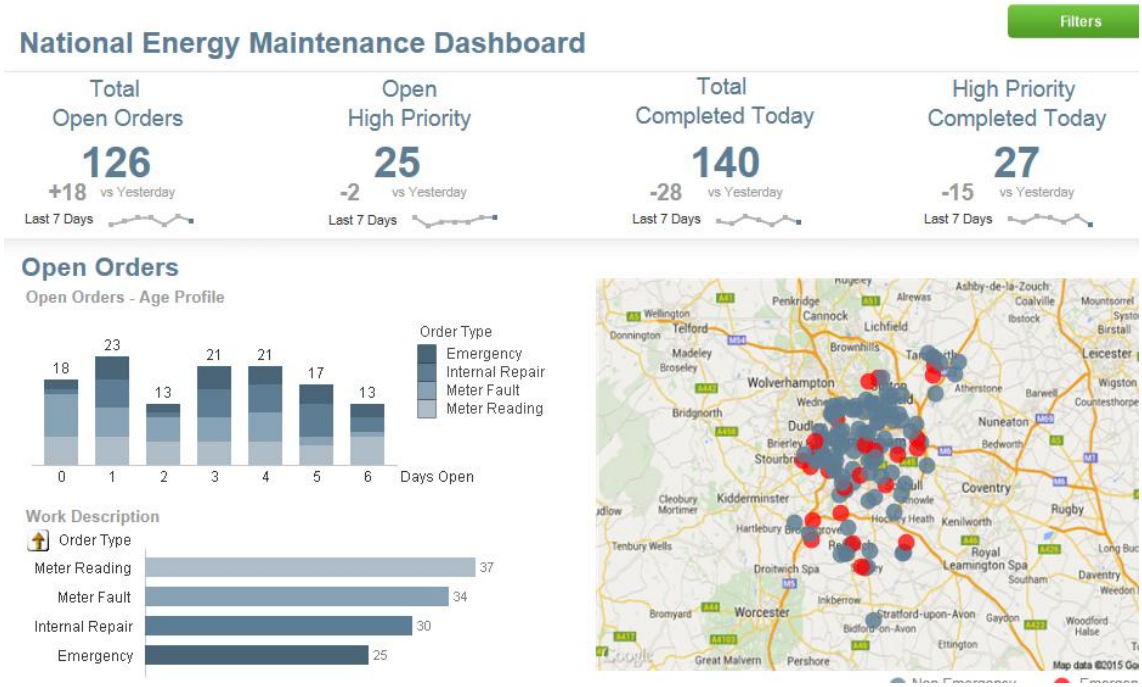


Figure 28. Workload visualization in Qlikview application (QuickIntelligence, 2015)

6.1.5. Data visualization in the case corporation

Active usage of visual business intelligence tools started with a data visualization project around three years ago when Qlikview tool was taken into use in the corporation. Now the Qlikview platform includes dozens of dynamic visualization application to a large variety of business users from different business lines, functions and organizational levels of the company. The focus is mainly on data level information and the level of visuality in the applications is around average of Qlikview's capabilities.

Other visual working methods are also used in the corporation and they are implemented to wider use all the time. For example a new project methodology relies on data that is visually presented onto multiple white boards. This method is used in the corporation and it is very well received in many functions and locations. Also visual management is utilized in some locations. Because the organization is adapting many types of new visual ways of working in their functions - the employees are more open to visual business intelligence tools as well. This creates a good base to develop processes and communication to more visual form.

Discussions with different persons in the organization revealed different types of desires for visualizations. Like one project participant said "there is a difference how older and younger people would like to see the data" when we were discussing about different chart options. But in general the need for more visual data and information was clear. The case corporation does not utilize coded data visualization in a large scale but there was interest towards that type of visualizations as well especially in sales department.

The development of data visualization has been fast with Qlikview and through that many processes have been able to unify and improve. Also the transparency has increased tremendously when reporting forms have been combined and data has been formed to more analyzable form. There is still a lot of work to do and problems to solve to have satisfying level of transparency in all demand-supply chain. These problems and other findings are presented in next section.

6.2. Fact-finding: Defining transparency in case corporation's demand-supply chain

After analyzing the demand-supply chain and data visualization in the case corporation, the fact-finding phase starts with interviews conducted with four representatives of the organization. Interview structure can be found in appendix 1 (Interview 3). In fact-finding phase the goal is to get better insight of transparency and decision-making in corporation's DS-chain and discover development issues that could be tackled with visual business intelligence tools.

Transparency was earlier defined as **"**Organizations and its employees' ability to see processes over all business lines and base decisions on reliable data" (Table 3). But as was mentioned before, transparency can mean very different things to different people depending on their position in the organization for example. How transparency is seen in the target organization and especially in demand-supply operations was clarified by interviewing four key persons in different functions. Interviewees are shortly presented in table 9 and the interview structure can be found in appendix 1.

When asked what transparency means to them and their organization and demand-supply functions, interviewees brought up a large variety of features of transparency. Representative of management said that the base for all transparency is the need to know organizations customers, suppliers, resources, assets and finance. Representative of engineering said that in order to have transparency it is important to see and understand the complexity of the business and acknowledge risks and opportunities.

All interviewees mentioned communications as one of the important factors related to transparency. They also stated that communication creates both internal and external transparency. Reporting was seen as one part of communications that creates transparency because through that different parts of the organization can communicate their activities to other parts. Transparency created by communications was seen good in such businesses in which most of the projects were quite small because these project teams communicate a lot with each other. Large projects communicate well inside the project but the communication between projects could be improved to increase transparency.

All of them also mentioned that right, accurate and trustworthy data is one attribute of transparency. And what's more, there has to be an easy access to it both in information systems and between employees. Old way of thinking "Shared knowledge is lost knowledge" deteriorates transparency. To have transparent information, the chain of information has to be united. With multiple information systems and databases information extracted from one has to be able to be connected to another information set in another system so that the connected data creates meaningful information for the viewer. For example customer data in CRM and financial figures in finance systems. This information can be interpreted as positive when studying only CRM data but when connected to data from financial database, the resulting interpretation can be completely contrary to the first one. For example when CRM data shows that a customers has been buying many products from the organization but financial data reveals that the customer has paid only a small fraction of them. The network of information systems has to be planned so that each system can be connected and data from one supports and ads insight when connected to another. The same goes with people. With a lot of partners, subcontractors and suppliers the network has to be coherent to have transparency in the demand-supply chain operations.

According to the management representative; to build up knowledge and good decisions on accurate and well-connected data, data visualization viewers have to have the possibility to create different type of groupings of data. This way they can survey it from different angles, make interpretations, drill-down from large data masses to individual entities and figures to get insight on what is happening and why. To have transparent data it cannot be too digested beforehand so the viewer has more options to study it.

One important part of transparency particularly in demand-supply chain is schedule. Well communicated, transparent schedule helps different steps of the chain to work effectively together. When sales and delivery projects are scheduled as correctly as possible, it is easier to plan how much resources is needed in each phase of the projects. Also orders to suppliers can be optimized with minimal effort. Figure 29 sums up the issues brought up by the interviewees into four categories of communication, accurate data, networks and business sense. Each of these categories improve transparency in their own way in demand-supply chain as well as in other organizational operations.

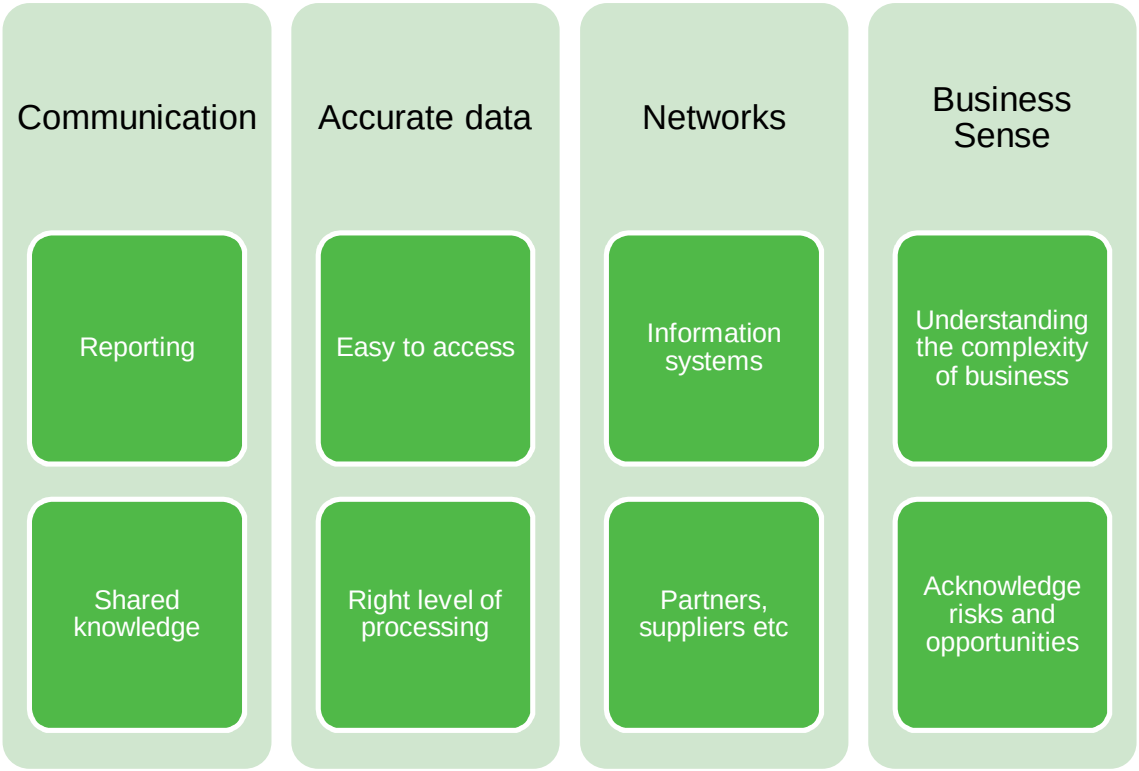


Figure 29. Transparency in demand-supply chain

Next interviewees were asked "where transparency is most important when it comes to making business?". For this interviewees highlighted forecasting of sales - because it determines many processes and resource usage afterwards, transparency and communication of success and failure – because both are important learning points and keys to development. Representatives of sales also mentioned work role casting. Transparent roles in projects and organizations make it clear what are everyone's responsibilities and tasks and finding information is also easier because you find the right person fast. Other issues in which transparency was seen important were: resources related to competence and load, requirements, timing and schedule, risks and opportunities and installed base of ours and competitors' products.

Interviewees were also asked about the current state of transparency in their corporation and especially related to the issues they marked as important in the previous question. Even though transparency has improved in the last few years according to representative of management; representatives from sales said that the current state is still only satisfying. Engineering manager brought up that transparency has improved with the help of new communication tools like video connection for Pulse meetings and Lync in general and new ways of working (Pulse).

But, according to the engineering representative, the problem now is that management is not taking necessary actions to fix the problems that have been found out with the

improvement of transparency. Communication between management and project organizations is too much based on financial figures that the real information concerning the project is left out and therefore transparency is not on a high level. Also, risk assessment is done in siloes which decreases transparency on their part. Related to the current state of data transparency in the corporation, management representative mentioned that, for example, for installed base, the exploitation of data is limited because the data and information comes from multiple databases and the level of accuracy varies between them.

Interviewees also listed problems that in their opinion should be solved to increase transparency. Identified problems included scattered risk assessment, false, hard to find, wrong leveled or otherwise useless data in information systems, data linkage problems between systems, hushed communication of requirements, inadequate communication of success and failure stories, unclear roles in sales and delivery operations in general and even more after reorganization of the organization. Also the large amount of partner and subcontractor employees was considered as problem for the competence resources because when the number of own employees is reduced, important competences might move to a partner or subcontractor.

So what can be achieved with transparency? According to the interviewees, by improving transparency it becomes easier to forecast changes in the business environment and guide the organization to the right direction. Employees are more motivated to follow this direction because the reasons for the chosen direction are transparent. They are also able to focus more on the actual work they are doing when working roles, organization's strategy and goals, and information sources and communications are transparent - instead of spending time searching for the right person or information for example. Improved transparency and forecasting abilities also enhance organization's reputation and credibility amongst stakeholders because the organization can, for example, communicate more accurate financial data to shareholders and send orders earlier to suppliers.

When asked if data visualization could have a part in solving some of these problems all interviewees responded yes. They think that data visualization can increase transparency because it is easier to get insight of large data sets from visualizations than when the same data is heard or read. This way it is easier, for example, to communicate workload pressure or achieved changes to others. Visualizing data presents it in a clearer form and therefore can have good impact.

All of the interviewees had also doubts about data visualization. Management representative made a notion that if the data is too formatted and handled it represents only the vision of the person who designed the visualization. Sales representatives had similar concerns. They said that if the data that is being visualized is someway wrong, visualization will highlight the wrong message greatly. Engineering representative said

that visualizations seldom work on their own. The “rules” of visualizations have to be known to be able to interpret them correctly.

6.3. Conceptualization and planning of actions for therapeutic stage

This section conceptualizes what are the issues that could be improved in the target organization and presents an action plan for the next stage of the research. The material collected so far comes from:

1) A conversation with a sales manager related to sales operations in general and how data visualization could be advantaged in sales
2) Another conversation with engineering manager about engineering process and data visualization in engineering and delivery
3) Three interviews with four key persons in the organization related to transparency in the corporation
4) Research done using the corporate information systems.

Current level of transparency in the corporation was seen to be improving in last years because of new ways of working and communication improvements. Still the level of transparency was seen to be only satisfying. The supporting research question; “why transparency is wanted in the case company?“, was answered in diagnostic stage through the interviews. Interviewees rose issues like better commitment, easier communication, clear work role casting and ability to focus on one’s work as some of the reasons why improving transparency is something they want to be done in their organization. Interviews conducted in diagnostic stage also answered another supporting research question: “what are the current problems related to transparency or the current information needs that could be solved with data visualization?”. Data problems were mentioned for one of those issues that could be solved with data visualization.

Based on the interviews and conversations during diagnostic stage, there are a number of issues related to demand-supply chain operations that could benefit of visual business intelligence tools and data visualization. For example - discussions with sales representative showed that the level of sales data visualization is currently satisfying with Qlikview application for sales but further development is needed. To further improve the visuality of sales information, following ideas occurred in the diagnostic stage

1) Visualize the accuracy of sales forecasting
   - To see how well the organization can predict future sales
2) Visualization of sales reporting
   - Current table-form reports are slow to interpret
3) Visualization of sales funnel and the movements of sales projects in it

4) Visualization of the sales costs
   - To see how money is spend during the sales process and to learn from this information
5) Sales material update to a more visual and digitalized form, for example 3D models of products
   - To able us serve our customers better and to show as good information about our products as possible
6) Sales references material to digitalized and visualized form
   - Currently sales reference material is in huge word-document
7) Visualization of sales projects in different project phases
   - To see and predict upcoming resource needs

Because the goal is to improve transparency in the whole demand-supply chain, not just one function, most of the visualization suggestions for sales operations are too narrow in scope. From the visualization ideas just presented the visualization of sales funnel is one that would have the largest impact in the whole demand-supply chain.

Representative of operational excellence highlighted that in order to get better transparency in the whole demand-supply chain, it would be important to visualize as high level process as possible. He presented an idea of demand-supply planning visual simulation tool that could combine information of sales projects and resources handled by engineering department. This data could be presented in visual form and the tool could be used to simulate changes in the demand-supply chain. Simulation tool could increase transparency because it could be used as support in communications and reporting operations and it would combine data from different operations and databases.

The most significant findings in diagnostic stage are presented in figure 30.

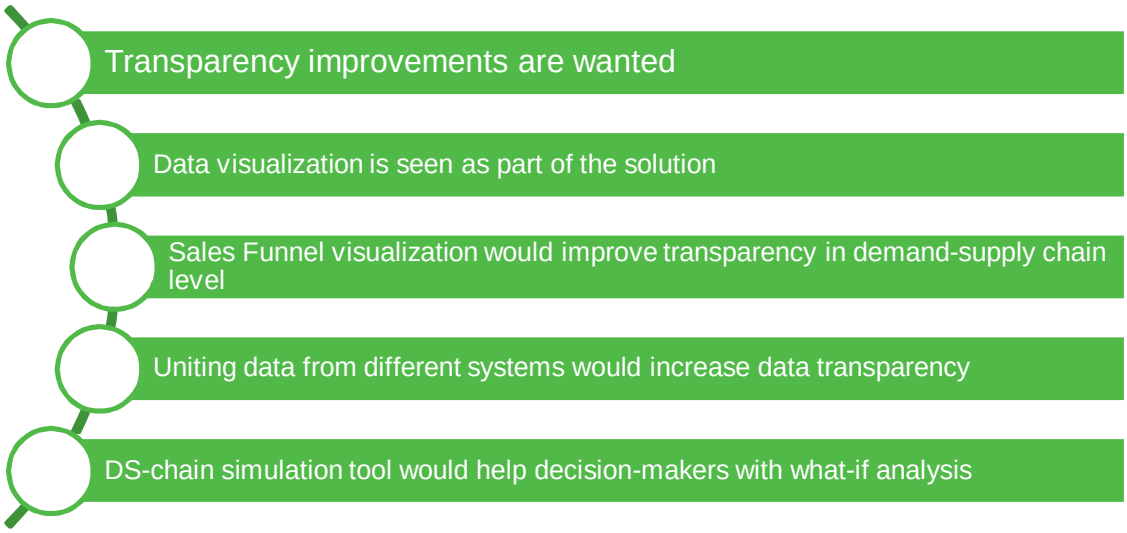


Figure 30. Summary of findings in diagnostic stage

Based on these findings, action steps to be performed in the therapeutic stage can be created. To increase transparency in the target organization’s demand-supply chain a visualization of sales and delivery projects are created. With this tool, different level management can see how projects are lined in the sales and delivery funnel. Next step in the transparency improvement plan is to create simulation tool on top of the visualization tool to able managers make simulations in the demand-supply chain. Based on these simulations they can predict what will happen in the project portfolio if projects move in time or sales projects are won or lost.

7. THERAPEUTIC STAGE: Development of improvement tools

Therapeutic stage includes the last two phases of an action research: implementation of action and evaluation. In therapeutic stage – the issues rose in diagnostic stage are turned into actions and results. Demand-supply chain visualization and simulation tools are created to test the concept of demand-supply chain visualizations and simulations for better transparency to the DS-chain. Firstly, issues related to the starting of the development are gone through in the section 7.1. A tool for the development is chosen and the concepts of demand-supply chain visualization and simulation tools are clarified. The tools are developed in co-operation with representatives from sales and delivery functions to create as agile development project as possible. The latest versions of the tools are also presented in the section 7.1. The last section 7.2. includes the evaluation phase of the research which includes the implementation and evaluation of developed tools. Finally section 7.3. presents a summary and findings of the therapeutic stage. Based on these findings suggestions for further development and deployment of the tools are created and presented in chapter 8.

7.1. Implementation of action: Development of demand-supply chain visualization and simulation tools

Visualization and simulation of the demand-supply chain is created because of the action plan created in diagnostic stage and because enterprise modelling can help managers to understand the complex and dynamic environment and to design new solutions to improve their organizations performance (Lyons et al. 2012). Different kinds of visualization and simulation tools and models can support decision-making by permitting the evaluation of the operating performance prior to the execution of a new design or a project and therefore permit the evaluation of benefits derived from the consideration of alternative scenarios (Lyons et al. 2012).

The goal of these tools is to improve case corporation’s capabilities in forecasting sales outcomes and resource demand. The scope is simplified in figure 31. Left side of the fourfold table with realized sales and resources is already well managed in the corporation but the right side of estimated sales and resource requirements could be enhanced.

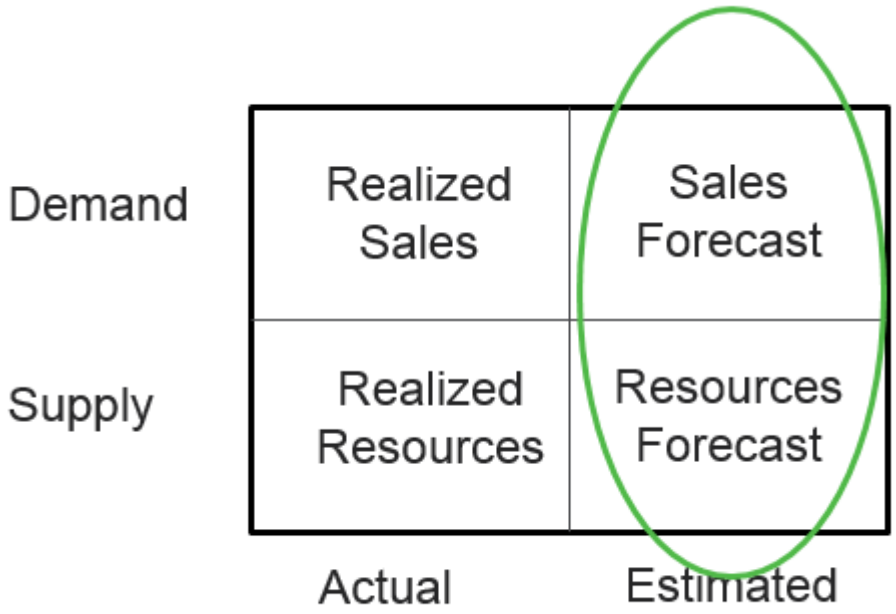


Figure 31. The goal of the developed tools is to improve transparency on the forecast side of demand-supply chain.

Used platform for the tools was selected from the four alternatives presented in the chapter four. A valuation of six attributes was used to find a platform that would fit the technical requirements and usability requirements of the target organization. These attributes were evaluated in scale of one to five, one representing the worst result and five the best.

These valuation attributes were:

1) Visuality: How well the platform visualizes required data?

2) Prize: What are the costs of purchase, development and use? Purchase price of platforms that are already in use is not included.

3) Compatibility: How well the platform fits to the existing tool palette, data structure and ways of working?

4) Distribution: How easy it would be to distribute a demand-supply simulation tool developed with this platform to all required users?

5) Usability: How easy to use the tool would be on this platform?

6) Scalability: How easy it would be to scale for different kinds of data sets and even for different purposes?

Table 11 summarizes the points given to the platforms and the ranking formed. Based on this valuation Qlikview was selected as the appropriate platform to build the

demand-supply simulation tool on with 24 points. It scored steady 4 points on each attribute.

Table 11. Comparison of possible tools for demand-supply simulation tool

	Excel	Infographic	Qlikview	Coded data visualization
Visuality	2	3	4	5
Prize	5	4	4	3
Compatibility	2	1	4	3
Distribution	2	2	4	4
Usability	2	3	4	4
Scalability	1	1	4	4
Sum of points	14	14	24	23
Ranking	3.	3.	1.	2.

The development process of visualization and simulation tools are parallel projects because the ultimate goal is to have them in one tool. The main difference between these tools is that the visualization is created from static data and the simulation part able the user to make alterations to the data and see how the visualization part changes.

Tools are built on existing data that is related to sales and delivery projects and workload estimations and actuals. Also some example data is used to create different scenarios to examine. Like mentioned above, Qlikview, which is already widely used tool in the organization is chosen to be the platform for the tool because of the valuation done and because of its familiarity in the organization. Also the company Qlikview environment already includes applications build for sales and workload reporting that can be exploited in the development of these tools. Coded data visualization tool might have been better option in terms of wider opportunities for visualizations but due to the restricted schedule and a hope for easy and fast improvements the already existing tool became a better option.

Development of the tool is done as agile way as possible with weekly and monthly meetings with different representatives of sales and delivery functions. The process is started from the sales part of the demand-supply chain with creation of visualization of the sales funnel for one business unit in the target organization. More thorough report of

visualization tool development is presented in next sub-section 7.1.1. At the same time with the visualization development the development of the simulation is started. This process is presented in sub-section 7.1.2.

7.1.1. Demand-supply chain visualization tool

The goal of the visualization tool is to collect data from different sources and form a visualization how projects develop from sales projects to delivery and warranty projects. The development started from sales phase of the demand-supply chain. A visualization of on-going sales projects was created based on paper sketches. The idea was to visualize sales projects on a gantt-type schedule chart (figure 32) with colors representing different sales process phases. This would have given vital information on current process phases as well as history data. In the end this feature was decided to leave to upcoming versions because the Qlikview tool did not perform in a desired level with these calculations. Also there was some issues with the data model collected of the sales projects.

Current version of the visualization tool, presented in figure 32 presents data from the corporation CRM tool related to sales and delivery projects. Main visualization is the project schedule view that shows main events of projects with colors, dots and lines. The lower visualization is a bar chart that divides projects into categories based on selections done in the three cyclic groups under the rotating arrow –signs. With the bar chart, viewer can visualize amount and type of projects for example per sales manager or product engineer which demonstrates workload in a rough scale. He can also visualize project amount by time division and do many other analysis based on the data provided from the CRM. These two parts of the tool are the most visual features it has. To able more thorough business analysis, Qlikview has a good capacity to delimit data and able drill-down analysis with clicking opportunities. In demand-supply chain visualization tool the left side bar is meant for narrowing data for deeper analysis.

The tool uses preset colors with important information highlighted with bright red color to guide viewers' eyes to the most important parts of the visualization. Two buttons are provided to narrow time selection into next six months or another option starting from last month to next 12 months. There is also buttons for estimated and back-up projects which are the most important on-going projects. With these small assistants, the user can easily pick up important data from the overall dataset.

Figure 32. Demand-supply chain visualization tool

Next step in the visualization tool development project would be to include data related to on-going delivery and warranty projects from Project Management tools. To make this easier current data model needs some improvements in company information systems.

The implementation of resources and actual delivery and warranty projects was done on an example level during therapeutic stage. Next is presented different examined options on how to improve transparency on this part in demand-supply chain. Chapter 8 shows the suggested choices from these examples. To be able to visualize (and later on simulate changes in) resource data sets need to be on an accurate level. Three different possibilities were acknowledged:

1) Deeper monthly planning based on the current way of resource planning
2) Competence level resource data
3) Three scale ranking for projects and engineers

Next examples explain further what these options include and show how resource data of engineering hours could be recorder, visualized and used to form new insight on the resource usage based on these three options. Figure 33 shows a simplification of the hierarchy of engineering function with five potential levels to review the workload on.

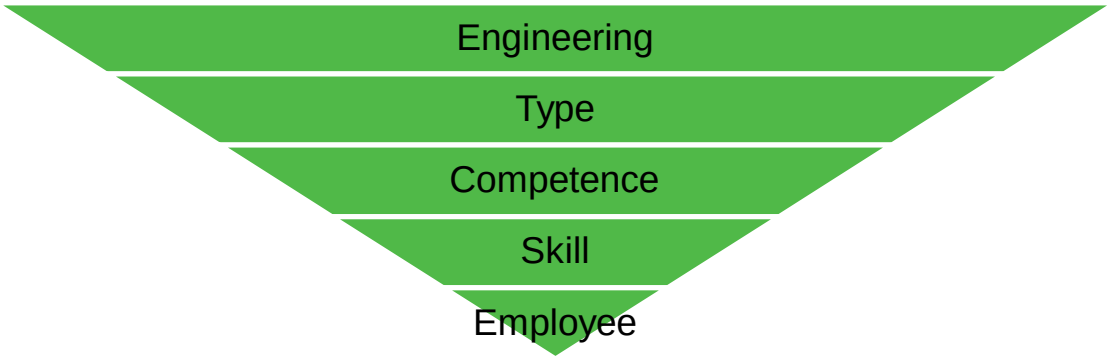


Figure 33. Hierarchy of engineering workload

Deeper monthly planning

Currently engineering workload is being planned on monthly bases. Planning could be extended for larger amount of data to get better knowledge of resources. With this solution the level of information would stay on the current level but it would be deeper for larger amount of projects than before. This way the management would see better how resources are needed and used.

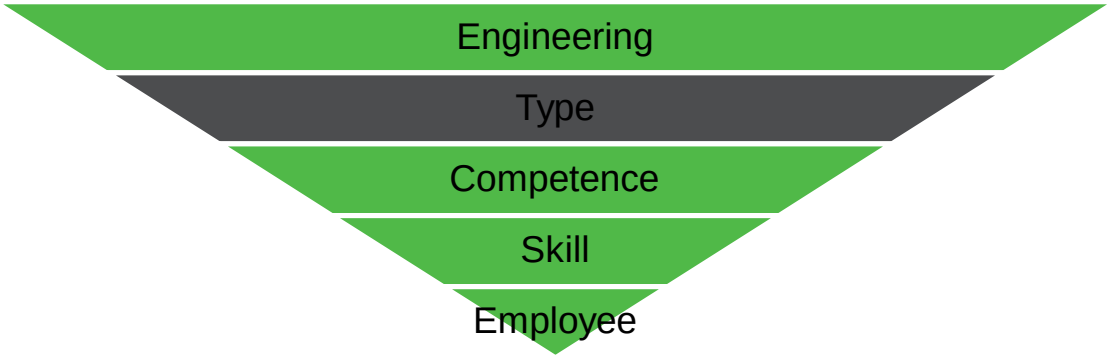


Figure 34. The level that deeper monthly planning produces data

Competence level resource data

Competence level resource planning is familiar option. That is why competence level surveillance is interesting possibility to increase transparency in resource demand and supply. With competence level data, the organization gets better insight of which competences are most used now and with the forecast of which are most needed in future. When this information is linked with company competence lists, that show current supply of those competences, decision-makers get important insight of the state of demand-supply ratio of key competences.

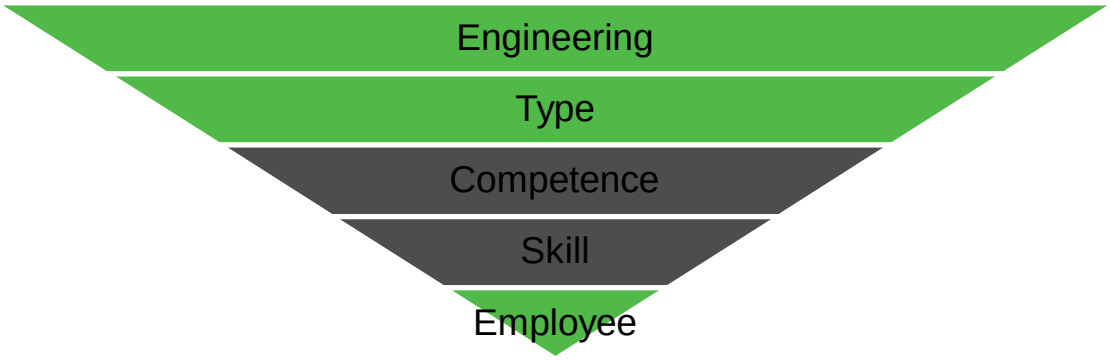


Figure 35. Levels that competence level resource planning produces data

Figures 36 and 37 show example visualizations of competence based workload data. With competence level workload data resource needs can be examined (for example) per project (figure 36) or per resource (figure 37). The basic idea is the same as currently used but the insight is greater. The same method can be used to create workload data on skill level too. Linear lines can be used to show the supply of resource. This supply can come from competence lists or it can be determined on monthly bases.

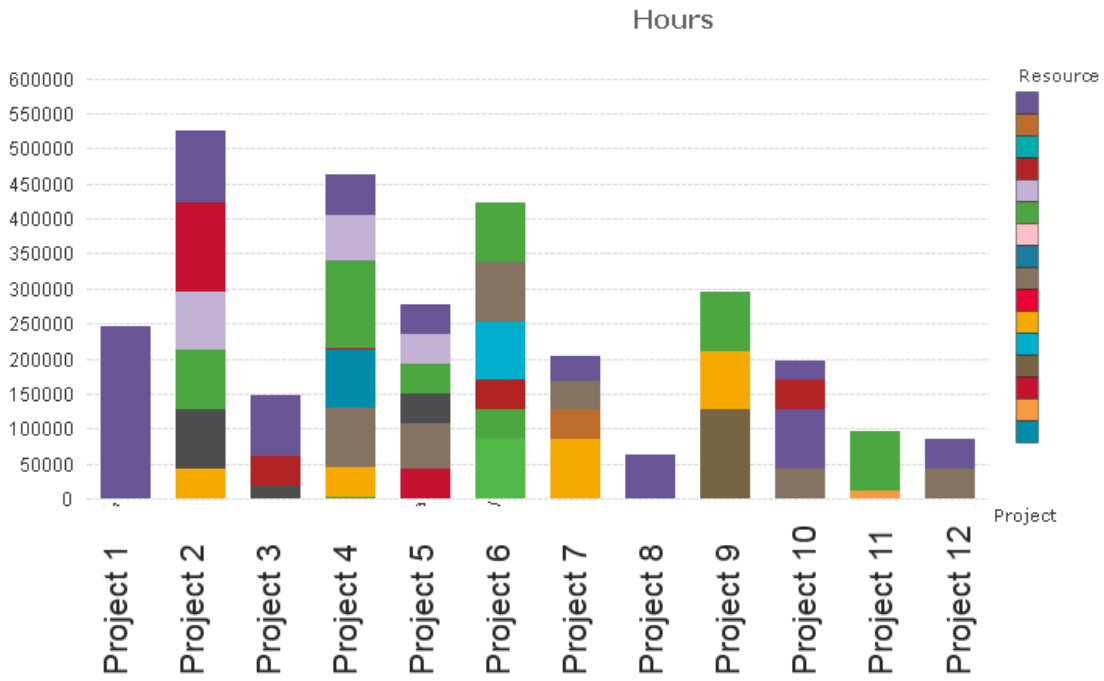


Figure 36. Workload visualized on competence level. Organized by project.

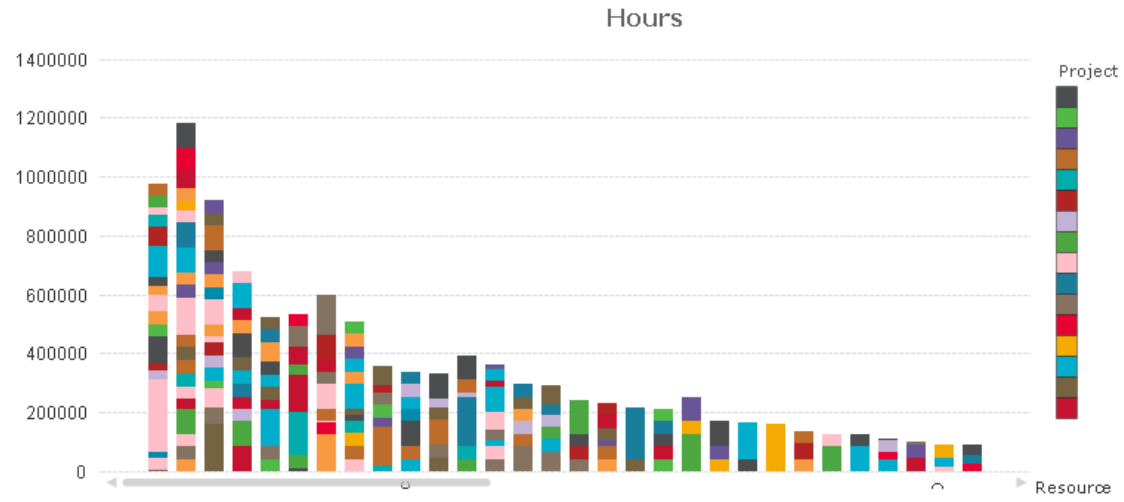


Figure 37. Workload visualized on competence level. Organized by resource.

Previous example figures show colors based on resource or project but colors can be used to demonstrate other things as well like the level of load. Figure 38 shows workload per resource with traffic light color coding. Red bars show resources that are in overuse, yellow bars represent resources that are close to be overloaded and green bars are resources with good workload. This visualization shows clearly resources in need of attention at the moment.

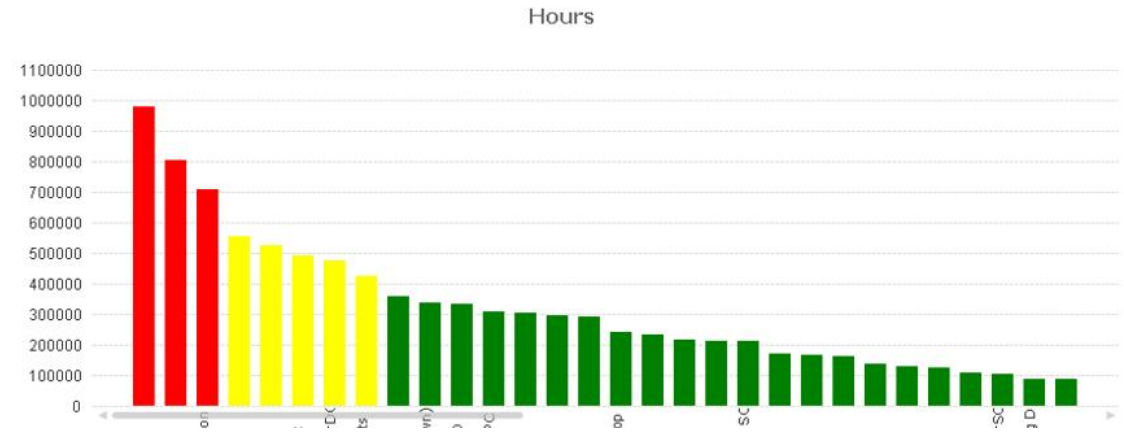


Figure 38. Resource visualization example with traffic lights

Three scale ranking

Creating and maintaining process to keep up on required competences per projects and current supply of competences can be laborious in a company with +10 000 employees. To improve visibility to resource load with minimal effort a three scale ranking of projects could be kept per employee involved. With uniting parts form competence level resource surveillance and three scale ranking – it could also be used on a higher level.

In three scale ranking each project would be marked as laborious, normal or easy for every important skill/competence/participant. This way more insight is created with

minimal effort on what type of projects each employee, skill or competence is involved in. For example if one employee has three laborious projects on-going and another one seven easy ones their manager can easily see that their workload is quite the same. Before it would have shown much less information.

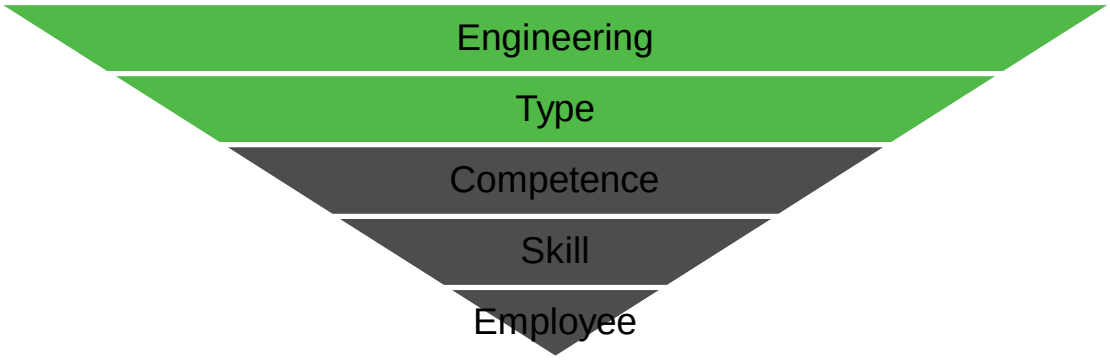


Figure 39. The level on which three level ranking produces data

7.1.2. Demand-supply chain simulation tool

Demand-supply chain simulation tool development was started separately but at the same time with visualization tool. The goal is to unite these two tools into one interface. Simulation's goal is to enable managers to examine what-if scenarios with their data.

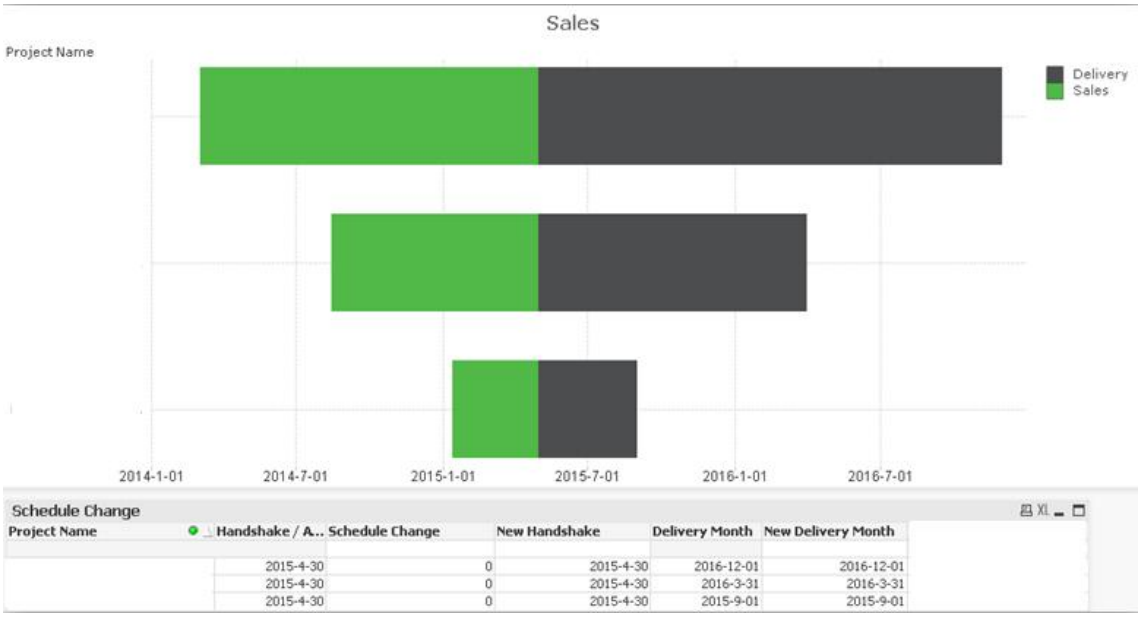
Demand-supply chain simulation is a technique that can support a multi-decisional context by facilitating complex what-if analyses evaluating benefits derived from alternative scenarios (Lyons et al. 2012). Demand uncertainty, in particular, is an important factor in the demand-supply chain design because it affects many operations (Lyons et al. 2012).

Simulating demand-supply chain can have different goals depending on the demand-supply chain structure and the role of the person doing the simulation. Terzi and Cavalieri (2004) structured these goals into three subcategories of objectives, processes and morphology. These goals are presented in table 12.

Table 12. Demand-supply chain simulation goals (Adapted from Terzi & Cavalieri, 2004)

Objectives	
Network supply chain design	Simulation is used as a decision support system for logical modelling and industrial node configuration or localization (for example placing a supply chain node in a determined geographic site)
Supply chain strategic decision support	Simulation is used to evaluate strategic alternatives (for example, vendor managed inventory versus conventional downstream replenishment)
Processes	
Demand and sales planning	Simulation is used to deal with dynamic, hard to predict changes in demand generation
Supply chain planning	Simulation is used to production planning and distribution resource allocation, under supply and capacity constrains
Inventory planning	Simulation is used to multi-inventory planning
Distribution and transportation planning	Simulation is used for distribution center, site localization and transport planning in terms of times and costs
Production planning and scheduling	Simulation is used to simulate production management of the manufacturing nodes
Morphology	
Supply chain ownership	Simulation is used to see differences between single ownership and multi-ownership
Supply chain levels	With regards to the number of tiers within a supply chain

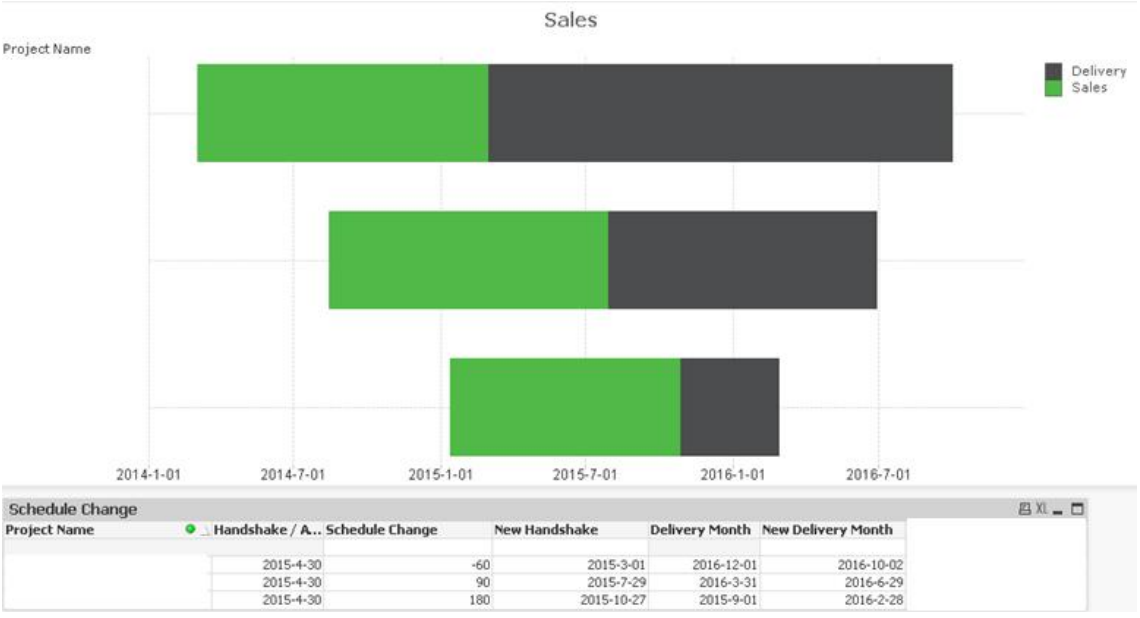
Main objective for the corporation simulation tool is to support decision-making by enabling managers to do analysis by changing attributes in demand-supply chain data. For example sales or delivery project schedules, financial data or scope. Simulation tool shows what those changes do to other parts of the demand-supply chain such as resources. This way demand-supply chain simulation tool can also support demand and supply planning processes. Figures 40 and 41 show parts of the demand-supply chain simulation tool in which the schedule visualization can be altered by changing handshake dates from the table below.



Schedule Change

Project Name	Handshake / A...	Schedule Change	New Handshake	Delivery Month	New Delivery Month
	2015-4-30	0	2015-4-30	2016-12-01	2016-12-01
	2015-4-30	0	2015-4-30	2016-3-31	2016-3-31
	2015-4-30	0	2015-4-30	2015-9-01	2015-9-01

Figure 40. Project schedule with no changes



Schedule Change

Project Name	Handshake / A...	Schedule Change	New Handshake	Delivery Month	New Delivery Month
	2015-4-30	-60	2015-3-01	2016-12-01	2016-10-02
	2015-4-30	90	2015-7-29	2016-3-31	2016-6-29
	2015-4-30	180	2015-10-27	2015-9-01	2016-2-28

Figure 41. Project schedule with changed handshake dates.

Visualization of simulation tool is built similar way with visualization tool because, like was said, in the end they will be in the same tool. When the data in simulation tool is dynamic and connected these changes presented in figure 41 will alter other company data and create a what-if analysis.

7.2. Implementation and evaluation of developed tools

Implementation was set as one of the research methods to be exploited in therapeutic stage to tentatively implement created solutions so the project could go on even after the

thesis work is completed. The demand-supply chain visualization tool was implemented to actual use in one business unit for their sales representatives. Implementation was done with two informal training sessions in which the tool was also tested to ensure it contains right data and works correctly. A week after the implementation two of these sales representatives where asked feedback on how the tool is working and what have been the effects to the transparency and decision-making. Next section will present this feedback.

The development work of DS-chain simulation tool is still on-going and the implementation phase of it is not determined.

7.2.1. Measuring the effects of the demand-supply chain visualization tool

After a week of usage, users of the visualization tool were asked feedback on the tool. When asked if the tool has had or will have impact on transparency, a sales manager said that it will improve transparency because it will make it easier to share information with people and make it easier to communicate e.g. current sales pipeline or resource situation. With the improved transparency, the tool will help them to develop their decision-making process related to sales projects prioritization. It also helps the sales team to focus more on detailed items that need their attention because the visualization highlights these items. Sales manager also believes that the tool will have an actual effect on the decisions they will make. But after only a week of usage it is still hard to say what kind of effect.

Overall the sales manager is happy with the tool and says that it looks promising. When asked about the future development steps he says that they have some ideas to have financial data presented in same type of format to provide them better analysis of current situation and also to understand history trends and development better.

7.3. Findings of the development work in therapeutic stage

In therapeutic stage, a development project for demand-supply chain visualization and simulation tools was started. Through the development work many good, not so good and also challenging issues were found out about the chosen tool, processes and data.

After analyzing all collected material the researcher can say that the most important and pleasant finding is that all the persons participating in any way to the development of these tools have seen the potential of visualization and simulation tools in their functions and in their everyday work. Participating have been persons ranging from vice presidents to managers and from sales function to delivery and to operational excellence which shows that these tools can serve a large variety of users. It shows that data visualization can be used on multiple levels and functions in the target organization.

Current version of the visualization tool presented in figure 32 is currently serving only sales managers. Based on their feedback (presented in section 7.2.1.) it will create new insight already in current form. But still a lot of development work has to be putted into before it can serve larger user segments.

Many opportunities for resource visualizations were discovered. Next chapter 8 will suggest what the next development steps on that part should be. For the demand-supply chain simulation tool, it proved that the chosen tool might not have been the appropriate tool because of lack of functionalities when it comes to users changing data.

Developing these tools has risen some answers to the main research question “How data visualization can increase transparency and therefore enhance fast and fact-based decision-making in demand-supply chain?”. One being that while developing these tools, problems that complicate visualization creation, can also be ones that decrease transparency. For example data connections between different information systems. It has also become clear that transparency cannot be increased just by creating data visualization; one also has to make changes and improvements in the underlying processes and data models to actually improve transparency and thereby improve decision-making. Like figure 20 showed the building blocks of working demand-supply chain, the same way data visualizations have to touch and make changes in processes, data and people as well.

8. DISCUSSION AND CONCLUSIONS

This master's thesis has studied benefits of data visualization to improve transparency in target organization's demand-supply chain. Both literature and empirical study show that data visualization can increase transparency and therefore lead to faster and better decisions. Discussions and interviews with target organization's employees showed that improvements in transparency are wanted and visual business intelligence tools are wanted tools to make this happen. Empirical part showed that main problems in the development of visual business intelligence tools are often problems in data and complex processes under the visualized subject.

When designing visualizations the designer has to know how cognitive processing works and how humans make decision in order to be able to support user's cognitive tasks in the best possible way. The designer needs to know common errors happening in system 1 and 2; like the anchoring influence. He also needs to understand that users might not always know what visualizations best support their decision-making process. Good data visualization provides as much information for the system 1 as possible and also minimizes stress in system 2 by minimizing noise and letting the user focus on the most relevant information.

The study was divided into six milestones and an ultimate goal of improved productivity, efficiency and transparency. Feedback collected in the end of the project show that only little improvement could be achieved in all three metrics. But further development and implementation should improve at least transparency which was the main target of these three improvement goals.

Figure 42. summarizes the whole master's thesis project from the start of the project in September 2014 to ready thesis in May 2015 and development and implementation plan continuing in summer 2015. Solution –box in the lower right corner of the figure shows the visualization tool starting from the development of sales funnel visualization that is united with the simulation design eventually creating the combined DS-chain visualization tool.

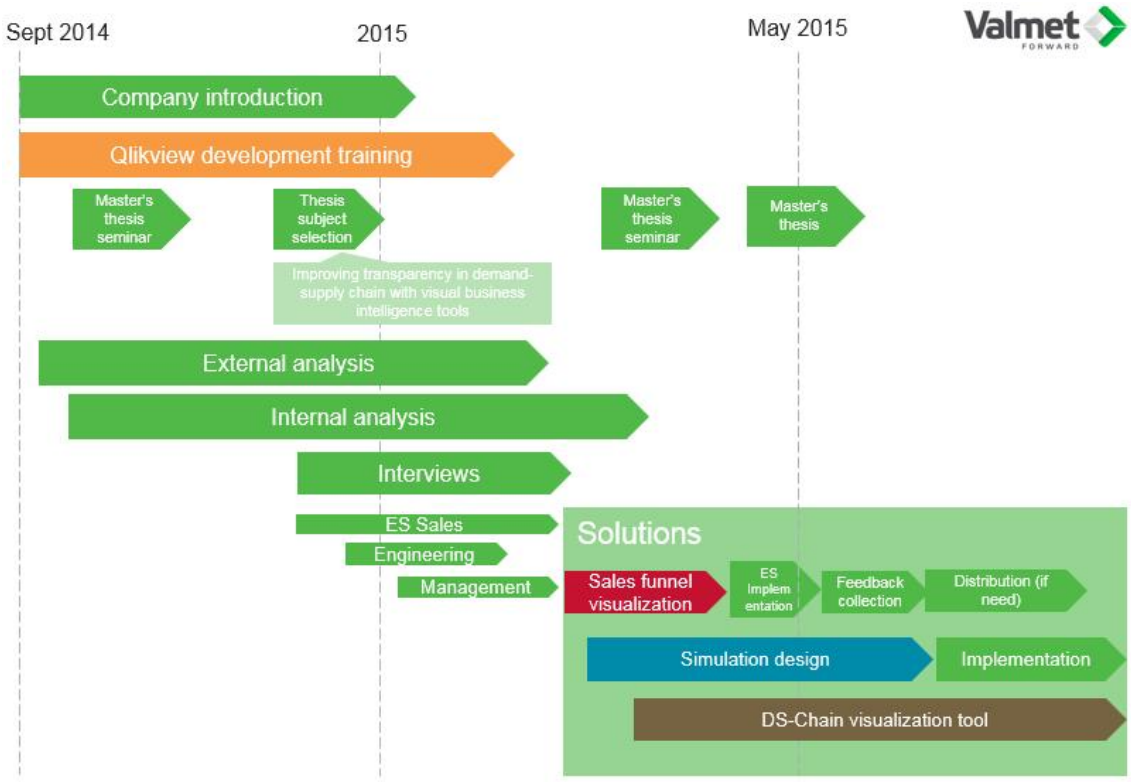


Figure 42. Master's thesis project with further development and implementation plan

The research questions guiding this project were:

Main research question

How data visualization can increase transparency and therefore enhance fast and fact-based decision-making in demand-supply chain?

Sub-questions

- Why transparency is wanted in the case company?
- What are the characteristics of data visualization that influence decision-making process?
- What are the current problems related to transparency or the current information needs in the case company that could be solved with data visualization?
- How the created solutions can help to increase the transparency in DS-chain and especially in sales and delivery operations and therefore help the decision-making process?

These questions were answered throughout the thesis. Based on interview 2: Transparency was wanted in the case company because it improves employee commitment, it increases abilities to predict future and act based on predicted and it also improves communication between employees and stakeholders. Characteristics of data visualization influencing decision-making process were presented in chapter 4.6. and

divided into three categories in figure 14 based on which decision-making process steps they influence the most. The most influential characteristics could be said to be data visualization's ability make the viewer ask new questions instead of just finding answers to existing ones. Data visualization also influences high-level cognitive processes that many decision-making processes in complex business environment are. They help people to internalize larger sets of data by improving our capabilities to group data and to retrieve information from long-time memory. And for the main research questions answers the characteristics presented on the decision-making part and interviews with organizations representatives on the transparency. To sum it all up we could say that visual business intelligence tools and data visualization increase transparency by compressing huge quantities of information into a form that human can easily interpret. Transparency increases when people get right information in right time through appropriate channel. This also reflects to faster and more fact-based decisions.

Problems in transparency in the target organization included communication problems, inability to do proper forecasting and challenges in collecting data from different information systems. Developed solutions, visualization and simulation tools could help the organization in future by enabling them to see their own project funnel from a higher perspective when schedule, resources and financial information are all in one interface.

To improve the results of this research a deeper knowledge of the company data set and selected tool would have increased the speed of the development work. Table 13 presents a summary of evaluation of the research project. The evaluation consists of four criteria with which the research process's success were evaluated. These four criterias were credibility, fittingness, auditability and confirmability. The research succeeded the most in fittingness and worst in auditability. Action research was very suitable for this research because organization's employees could be involved in all phases of the research. Also development ideas were easy to discuss with this type of research strategy. Research is not the easiest to audit due to only semi-structured documentation. All in all the research process went as expected.

Table 13. Evaluation of the action research process (Adapted from Street & Meister, 2015; Lincoln & Guba, 1985)

Criteria	Desirable action research characteristics	Evaluation of success
Credibility	The observations are recorded and analyzed in an interpretive frame Credibility is established through triangulation of information from multiple data sources Sufficient data must be collected to provide rich, deep insight	Credibility of this research has been on a good level. Observations could have been recorded in a more organized way. But because the information was coming from multiple sources (multiple interviewees, multiple internal data sources) the credibility is good.
Fittingness	Purpose of the research is to extend understanding of an issue The research should illuminate a theoretical framework that explains how the actions led to the favorable outcome	Action research fitted very well for the purposes of this study because organization's employees could involve in this research and development process
Auditability	Future researchers can clearly follow the decision trail used by the investigator	Auditability of this research is on satisfying level. Interviews are mainly repeatable because they were semi-structured and the development process of tools is documented in this thesis. Also the decisions made during the research are explained in this thesis.
Confirmability	Principle of interaction between researchers and subjects Data collection includes participatory observation	Changes and development ideas were introduced and discussed throughout the research process which increased the confirmability.

8.1. Suggestions for further development

To further improve transparency in demand-supply chain further development of the demand-supply chain visualization tool is required. The most important tasks would be adding information of delivery projects, resources and financial data to it. For this some data model improvements are recommendable. Also the resource planning has to be discussed and developed based on the issues discussed in chapter 7.1.1. With these development tasks the demand-supply chain visualization tool would visualize quite well the overall flow of the projects in the corporation demand-supply chain. It would serve management in delivery operations with improved visibility to on-going delivery projects.

The created visualizations should be examined further whether they support users' cognitive processes in the best possible way to create insight or not. Like was mentioned in chapter 4, user himself is not always the best one to tell if the visualization works in a desired way.

Table 14. Suggestions for further development

United company data	Competence level resource planning	Visualizations to support users' cognitive processes	Re-examine a proper tool for simulation tool

For the demand-supply chain simulation tool it would be advisable to re-examine if Qlikview is the right base for it. It is designed to work with data coming from other systems and not for changing that data. That is why functions needed for the simulation are not basic functions of it. Based on the development work done so far it seems that in order to get these functions to work, more programming skills would be required than the thesis writer has. So the development plan for the simulation tool starts with the re-examination of the base tool and then including a programmer to the project.

When the simulation functionalities are built properly and company data is enhanced; the simulation tool should start bringing actual value to users.

Research work I have done for this thesis shows that visual business intelligence tools are not so much studied yet at least in a frame of large industrial organizations. How human construct different kind of visual clues is quite clear already but the effect of visually shared information to decision-making should be studied more, especially in complex business environments.

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APPENDICES (1 piece)

INTERVIEW STRUCTURES

Interview 1: Sales processes

1) Could you shortly describe sales function in Valmet?
2) How is data visualization currently used in sales?
3) How could it be further exploited?

Interview 2: Delivery processes

1) Could you shortly describe what is the role of engineering in sales and delivery projects?
2) How is the planning of supply executed? And forecasting?
    a. Is the accuracy of forecasts followed?
    b. How are the changes reacted?
3) How could the predictability/predictions be improved?
4) How is the communication between sales and engineering planning constructed?

Interview 3: Transparency in organization

1) What does transparency mean to you and to your organization (and especially related to sales and delivery processes)?
2) In which parts or functions of the organization transparency matters the most for business?
3) What is the current state of transparency in these parts or functions?
    a. Where it is in adequate level, where it should be improved?
4) What kind of problems related to transparency should be solved? What would be accomplished?
5) Do you see that data visualization could be a part of the solution? Why or why not?

Interview 4: Benefits of demand-supply chain visualization and simulation tools for transparency and decision-making

1) Has or will the new tool improve transparency? How?
2) What are its effects to your organization's decision-making process? Will the tool change it in some way? Explain with few sentences why it will effect or why not.

3) How about the actual decision, do you see that the new tool can have effect on the actual decisions? Why/why not?
4) What would be the next development steps to even further improve transparency and decision-making?